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The cost conflicts of flexible manufacturing?

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THE COST CONFLICTS OF FLEXIBLE MANUFACTURING?

Submitted by Bill (W.J.) Lee
for the degree of Ph. D. of
the University of Bath, 1992.

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ABSTRACT: A dominant thesis in the analysis of flexible manufacturing is that accounting controls and objectives limit the utilization of technology such as FMS. It is demonstrated in this dissertation that companies do realise their manufacturing goals when introducing Flexible Manufacturing Systems. This is despite the superordinate formal position that accountants enjoy at many companies, and the biases in their pre-investment and cost monitoring techniques. It is shown by a study of 19 firms that have introduced a total of 21 FMS systems that it tends to be engineers, rather than accountants, who decide how FMS systems are deployed. The study has relevance to broader theories of wholesale shifts to either "Flexible" or "Fordist" futures. The evidence reported here demonstrates that different companies were introducing FMS to realise economic gains that were consistent with Mass Production, Flexible Manufacturing and Just-in-Time strategies. This indicates that the pattern of change is more piecemeal than the advocates of either "Flexible" or "Fordist" futures suggest.

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Chapter One.

1.1 Introduction.

When I started this project two significant changes were taking place in the economies of the developed world. Each had origins dating back 15 - 20 years. The first suggested the end of an era: many countries, including Britain, had experienced a major economic recession for the first time since the Second World War and a number of their key industries were encountering difficulties. The second was the development of microprocessors which allowed knowledge to be stored and transmitted cheaply. This raised hopes of invigorating ailing companies by bringing under the control of a single integrated computer system all of a firm's operations from the design of a product and the ordering of raw materials through manufacture to the dispatch of the finished goods, with their accompanying bills and dispatch notes. The collective term for this development was computer integrated manufacture (CIM).

From the late 1970s the engineering industry had witnessed some movement towards attainment of this vision as the computer based configuration of machine tools known as flexible manufacturing systems (FMS) were being developed and deployed in small but increasing numbers. However, in the USA, FMS systems were being used to produce a limited range of goods in large batches (Jaikumar, 1984). This had only brought marginal increases in the productivity of labour and, thus, minimal improvements to a company's overall economic performance (Jaikumar, 1986) (1). Greater benefits seemed likely if systems were deployed for the production of a wide range of components in small batches

(Jaikumar, 1984, 3, 8; 1986, 70; Jones, 1989, 44 - 5) as this would enable companies to cater to customer specifications, with corresponding increases to value added to products, and realisation of the qualitative improvements in technical capabilities which the new production system promised. In other words, there was a conflict between using system time for production purposes to increase the volume of output or using some time for development purposes to increase variety. American firms appeared to be pursuing the former route whilst the more successful Japanese firms were using their systems to machine a wider variety of goods in smaller batches.

The implicit dangers of not operationalising FMS for flexibility appeared to be accentuated by the similarity between the competitive advantages of flexible deployment of FMS systems and the economic order of "Flexible Specialization" which some authors such as Piore and Sabel (1984) had argued was evolving to replace "Mass Production" or "Fordism" in some regions of the industrialized world. Piore and Sabel contend that consumers are rejecting mass produced standardised products and selecting goods that are more suited to their individual needs and tastes. Thus, if companies are to succeed in the more differentiated markets of the future, they will have to develop new types of production unit to manufacture the wide variety of goods that are now being demanded. The introduction of FMS systems into the engineering industry appear to complement such a development, but as yet the systems have been used to machine standardised parts in large batches. Jaikumar (1984: 24, 4 - 6; 1986, 76) suggested that a major factor contributing to this misuse of FMS systems was the rationale of

Scientific Management; see Chapter Two below. This resulted in a division of skills at the point of production into programmers and operators. It has also led to the use of methods of cost control that emphasised maximum operating time. These have discouraged companies from using valuable production resources to change systems to different manufacturing objectives. The first issue of the relationship between skill distribution and the deployment of FMS in Britain was already the subject of a study by Scott (Scott, 1987; Jones and Scott, 1985) and did not require further investigation.

It was the second issue of cost control which Jaikumar had raised that stimulated my interest as it presented an attempt to bridge the theoretical and methodological gaps that had hitherto existed between the disciplines of management accounting and industrial sociology. As Kaplan (1984: 408) has pointed out, researchers into management accounting have developed complex theories of accounting behaviour based on simplified models of the firm which do not embody the complexity of existing production processes. On the other hand, industrial sociologists have conducted detailed research into changes in work organisation that have arisen from the pursuit of profit, but they have neglected to consider the role of management accountants who are a company's custodians' of finance (Littler and Salaman, 1984; 64; Armstrong, 1985; 130). It was Professor Jaikumar's fusion of insights that I aimed to emulate by conducting a similar study into the installation and use of FMS systems at firms in Britain. My initial intention was to examine the extent to which Scientific Management had influenced the development of cost control in Britain and the

effect which this was now having on the deployment of FMS.

However, on closer scrutiny I found a number of ambiguities in Jaikumar's argument which necessitated that I refined his terminology, investigate some of his assumptions and even broaden my area of study before embarking upon the fieldwork for this investigation. The particular aspects of Jaikumar's argument that demanded clarification were: (a) the exact sources of change and resistance to flexible deployments of FMS from within the enterprise; (b) whether it was possible to generalise previous production systems as dominated by scientific management-informed mass-production principles, and the only viable option being a change to flexible deployment of the intrinsically flexible FMS; and, (c) the influence of other accounting techniques and procedures, particularly pre-investment justifications, on the eventual use of FMS. Each of these areas will be discussed in turn as a means of providing a detailed prologue to the issues that are considered in the subsequent chapters of this thesis. Before that, Jaikumar's ideas will be explained in greater detail.

1.2 Jaikumar's thesis outlined: Scientific Management, Cost Controls and Productivity as Obstacles to Flexibility?

When expressed in its most stark terms Jaikumar's thesis may be understood as a description of the conflict between the logic of two types of philosophy - "Scientific Management" and "Flexible Manufacturing" - which he perceives to be present in modern manufacturing (2).

Jaikumar argues that, historically, "Scientific Management" has been the dominant philosophy (3). It originates from an era

when firms competed in markets for similar products on the simple bases of their relative price. At this time variable costs, particularly labour, constituted a high proportion of all expenditure. This had to be reduced if the companies were to gain a market price advantage (Jaikumar, 1986; 74 - 6). In logical terms Jaikumar presents "Scientific Management" as viewing labour as having a negative value; that is to say, its presence makes a firm less profitable. "Scientific Management" offered firms a means to reduce labour costs by increasing the productivity of workers through a sub-division of their tasks. This entailed a reorganisation of the whole company. White collar technicians, who were situated in offices, decided how work should be performed, whilst shopfloor employees carried out these instructions. Cost accounting was developed to measure the efficiency of this reorganised work process. It did so by counting the output from each individual worker at each stage of the reconstituted work process. Thus, "Scientific Management" pervaded a company's operations.

The "Flexible Manufacturing" philosophy finds its manifestation in the machine tool configuration of FMS. This facilitates a wide range of production outcomes. The absence of dedication in the system's hardware and the accompanying computer system allows FMS to be reprogrammed and oriented to new uses. The advantages of reprogramming are cumulative. The costs of their realisation are being reduced by the organisation of parts into families at different stages of the manufacturing process, and the transfer of the operator's knowledge that is used when machining one part to the machining of others within the same family

(Jaikumar, 1984: 7). However, such usage is contingent upon shopfloor operatives being given the right to act in an autonomous manner, and to initiate changes in the way that parts are machined, in order to develop knowledge of synergies. In "Flexible Manufacturing" philosophy multi-skilled workers are the cornerstone of successful companies and constitute a positive value. In other words, they are necessary to realise the full advantages of new systems which improve the company's competitive position.

Jaikumar (1986: 76) argues that the general economic context of what constitutes viable production has now changed. The steady displacement of labour - first, through the reorganisation of work tasks in Scientific Management and subsequently by the introduction of highly efficient machinery - means that most costs are now fixed. The low levels of labour that are employed limits the potential for gaining a competitive advantage through further reductions in staffing. Therefore, new measures which deflect attention away from the aggregate volume of inputs and outputs are necessary to monitor the performance of the company in the new environment (4). The continued domination of "Scientific Management" as manifest in the performance measures and architecture of the firm gives rise to the following undesirable consequences when FMS systems are installed.

(a) FMS systems are staffed by relatively unskilled operators who are not provided with the training necessary to understand the principles and mechanisms of Flexible Manufacturing Systems (Jaikumar, 1984, 38 - 41). In accord with the principles of "Scientific Management" this group of employees are taught to follow a number of definite procedures for operating FMS. They are

not entrusted with the knowledge necessary to change those procedures even when such changes would enhance the performance of the system (Jaikumar, 1986: 71).

(b) As with "Scientific Management" a separate group of people are responsible for deciding exactly how a particular system should be used. Project teams that are comprised of a number of non-manual staff are set up to supervise the installation and operationalisation of FMS. These tend to be disbanded shortly after the systems are operational (Jaikumar, 1984: 41, 46: 1986, 71). Programmers, who are marked off from operators both in terms of status and physical location, are allowed to change procedures (Jaikumar, 1984; 26). However, their general brief is "if it ain't broke, don't fix it" (Jaikumar, 1984: 24).

(c) Finally, there is the impetus given towards volume production of a limited range of goods by the system of cost control. This articulates the philosophy of "Scientific Management" and emphasises machine uptime and volume of output per labour input. The experimentation that is required to increase the potential range of uses of FMS is, thus, discouraged. Skinner (1986), whose analysis is of a similar genre to Jaikumar, describes the effect of cost monitoring on operators:

"work (takes place) in an environment where one is told what to do, how to do it, when to do it, is measured in minutes and sometimes seconds, is supervised closely to prevent any inefficiencies, and is paced by assembly lines or machines to produce at a rapid and relentless rate." (1986: 58. Jaikumar, 1984: 23 - 4, makes a similar argument.)

Skinner also reports the effect of current cost criteria on managers:

"Managers under relentless pressure to maximise productivity resist innovation. Preoccupied as they are with this week's cost performance, they know well that changes in processes or systems will wreak havoc with the results on which they are measured. Consequently, innovations that lead to, better service or shorter lead times for product changeover are certain to suffer." (Skinner 1986: 56. See also, Jaikumar, 1984: 44 for similar argument.)

All of this appears persuasive. However, there is an important omission in this part of Jaikumar's argument. That is he fails to explain why "Scientific Management" should remain as the dominant philosophy when there is a new and apparently superior one at hand. The gist of his argument is that the personnel of a firm introduce "Scientific Management" which is complementary to one historical period. In a subsequent era personnel at the same firm introduce a machine tool configuration that embodies the philosophy of "Flexible Manufacturing". The flexible manufacturing system and philosophy are compatible with the current time period. The later generation then employ their new machinery according to the anachronistic principles of "Scientific Management" even though this course of action is to their detriment.

Why such contradictory behaviour should take place is not made clear. If the principles of "Scientific Management" are so pervasive, how is a system that embodies a different philosophy introduced in the first instance? If the introduction of a system embodying new principles occurs because engineers, who initiate technical change, subscribe to a different rationality to accountants, who supervise the administration of accounting techniques, why are the latter able to impose their analysis on an engineering system in such an inappropriate way? Further, if an

accountant's actions are to the detriment of the firm why is there no challenge to his or her authority? These are issues that will be addressed in Chapter Two below. Before that, consideration will be given to the question of whether one application of FMS is naturally superior to another in the present context.

1.3 The Value of the Flexibility of FMS in the Present Context.

Jaikumar's claims of the superiority of flexible deployment of FMS are based on two assumptions: The first is that the fundamental quality of FMS is its flexibility; the second is that that quality coincides with the general economic conditions for its exploitation. The first assumption will be considered here by a critical evaluation of Jaikumar's example of Japanese firms which, he alleges, are pursuing a strategy of "Flexible Manufacturing" by exploiting the flexibility in FMS. The second issue will be considered below by means of a critical discussion of a number of theories on the long term trajectory of industrialised economies.

1.3 (a) The Over-riding Value of Flexibility in FMS? The Japanese Case Reconsidered.

Jaikumar equates the financial merits of deployments of FMS by reference to their flexibility in terms of the range of parts that they machine, and the ease with which they introduce additions to that range. Thus, for example, he (Jaikumar, 1986) praises systems at Japanese firms that machine an average of 93 different parts and criticises those in American firms which machine an average of just 10 parts. He attributes the latter to the pursuit of high levels of machine uptime. However, Jaikumar's description of Japanese

companies' deployment of FMS is not always supportive of his argument that their success is due to their pursuit of flexibility. Whilst he proposes a strategy of "Flexible Manufacturing" when he admonishes American firms for their pursuit of productivity ends, elsewhere he recommends Japanese utilisations of FMS that "have achieved untended operations and system uptime of an astonishing 90 - 99%" (Jaikumar, 1986; 72).

Given this inconsistency, it is not surprising that his claims about the source of the competitive advantage of Japanese systems are also incompatible with one another. Most regularly, the weaknesses of American systems are attributed to the principles of "Scientific Management", with its emphasis on system uptime and separation of conception and execution; and also the contingent absence of diagnostic and programming skills of system operators (Jaikumar 1984; pp 26: 1986; pp 71). At other times the competitive advantage of Japanese systems also stems from their emphasis on zero defects. Thus, when talking of the greater productivity of Japanese systems Jaikumar says:

"Where does so huge a difference come from? In a word, the reliability designed into the system. In Japan, system designers strive to create operations that can run untended."
[First emphasis is original, second emphasis has been added.] (Jaikumar, 1986: 72)

The consequence of this is a difference in emphasis on how the poor performance of American systems may be remedied. At one point we are told that American systems suffer from their deficient position because of the absence of multi-skilled workpeople at the point of production (Jaikumar, 1984; 41). At other times the advantage of Japanese companies is not attributed to the constant

presence of their multi-skilled design team but instead to the point of their withdrawal from a system which is when "the FMS achieves 90% uptime and untended operation" (Jaikumar, 1986; 75).

It would, therefore, appear that the deployments of FMS in Japan perform better than those in American firms on both of the criteria of flexibility and productivity. This is not inconsistent with the more general findings of other research that Japanese companies are more efficient than Western firms in the production of goods for both niche and mass markets (Wood, 1989; The Economist, 1991).

The general success of Japanese companies is often attributed to their manufacturing strategy of "Just-in-Time". Contrary to what Jaikumar's thesis implies, this did not involve a rejection of Mass Production/ Scientific Management principles but their adaption to the limited size of the markets in the East (Sayer, 1986). Sayer explains that the lower volume of throughput at the time of Japan's industrialisation meant that high transport costs could not be justified and this necessitated locating suppliers of materials closer to the purchasing firm.

The emergent clustering of dependent firms provided the infrastructure for the just-in-time (JIT) organisation of production. With JIT parts are purchased, brought to the factory, machined and delivered to the next stage in the manufacturing process just-in-time as machine capacity becomes available to carry out subsequent operations. The start, conduct and completion of the production process at the manufacturing firm is synchronised with the timing of customers orders to ensure delivery of products at the precise time that the customer wants them. Once such an

infrastructure was in place Japanese companies were able to make a conscious effort to reduce the levels of stock which they carried. This exercise was carried out between the mid-1950s and the mid-1970s when Japanese companies reduced stocks by one third (Williams et al, 1988) and the time of some of their changeovers between machining operations to between 6 - 8% of what they were originally (Kaplan, 1983: 692). These innovations were not matched by companies in the West. Japanese companies, thus, gain an advantage over their Western counterparts by avoiding the cost of purchasing inventory stocks, interest on their value, the rent of space to accommodate stocks and the personnel to administer them. Japanese companies have used the absence of stocks to identify defects in the production process and rectify them at source. This pursuit of "zero defects" allows Japanese companies to avoid the scrap and quality inspection costs incurred by Western companies.

JIT's focus on the levels of stocks means that it does not address directly the labour-machinery axis. Therefore, it cannot be perceived simply as extending the economic advantages of mass production (cf Scott, 1987). Nor, as may be read into Jaikumar's account, is it a natural complement or enhancement of the financial benefits of Flexible Manufacturing.

The simultaneous realisation of some advantages associated with Flexible Manufacturing, Mass Production and JIT may be possible at times. For example, JIT objectives often coincide with Mass Production ends. With JIT, labour productivity may rise because indirect labour is no longer needed to administer stocks (Williams et al., 1989), and because an intensification of work takes place. Turnbull (1986) reports that labour itself is used on

a just-in-time basis and operators mind an increased number of machines. These often come to a standstill whilst the worker is performing tasks elsewhere. The machines then need attention immediately the operator is free, so work intensification takes place by rotating the tasks of the employee. However, the Japanese example also demonstrates that there is a trade-off between some "Mass Production" and "JIT" objectives. The attainment of reductions in stocks has been at the expense of machine output (Williams et al., 1988; Oliver, 1990: 24). This is because: (a) the emphasis in Japan has been to utilise the time of the worker rather than the machine and this results in machines standing idle at some times; and, (b) the imbalance between the times of each constituent machine process and the absence of buffer stocks means that progress of parts through machinery at each of the processes is restricted to the time of the slowest.

Similar overlaps and divergences can be found between the use of resources in JIT and Flexible Manufacturing. Like Flexible Manufacturing, JIT employs general purpose machinery and multi-skilled labour (Tailby and Turnbull, 1987). What is more the reductions in the times of set-ups is an integral part of reducing the cost of flexibility whilst the emphasis on zero defects stimulates a desire to experiment with the production process. This is essential to Flexible Manufacture. Sayer (1986) details this last point in the following terms:

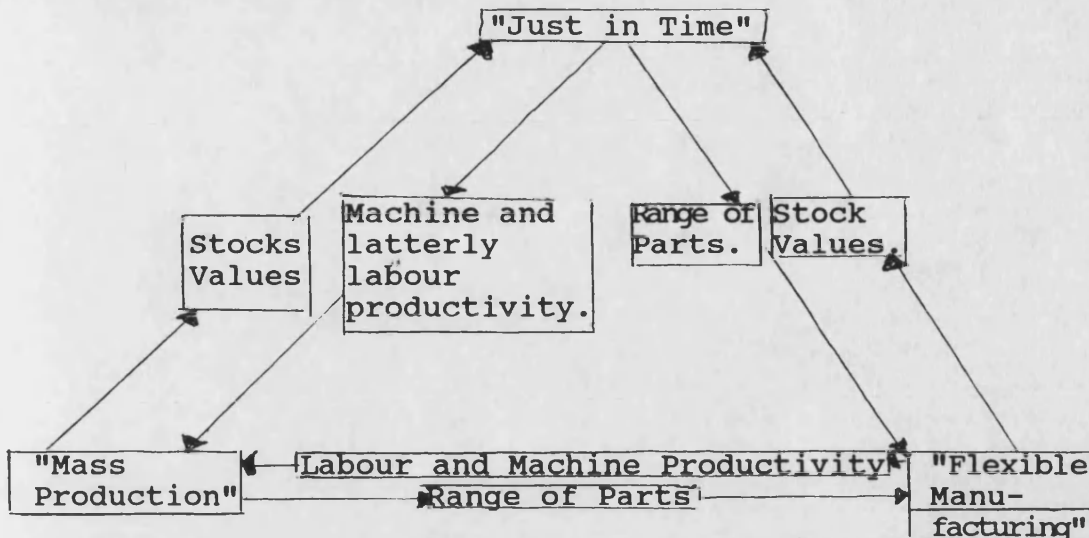
"The reduction of buffers stimulates a continual learning process, indeed ideally the production process never becomes entirely standardised and the "learning curve economies" continue long after the learning curves of

orthodox firms have levelled out. It is for these reasons that JIT is not simply a low-inventory system of production. It is a particular and sophisticated method of learning-by-doing. And this is a reason why Japanese firms have had so much success in out-competing established western firms which had treated their industries as mature and for which relocation to cheap labour countries was seen as the only way of improving competitiveness." (Sayer 1986: 53. Original emphasis.)

However, low stock levels also place restrictions on flexibility because the absence of available materials prohibit design changes (Production Engineer, 1981; Aggarwal, 1985) or any fluctuations in the numbers demanded by a customer (Sayer, 1986; Tailby and Turnbull, 1987). In addition, attainment of short set-ups may put limits on the type of set-up that can take place and, by implication, the flexibility of the machine (Maskell, 1986).

It should be clear from the preceding that as integrated systems such as FMS offer the opportunity to reduce inventories, Jaikumar is wrong to represent potential utilisations as either akin to unprofitable Mass Production deployments or profitable Flexible Manufacturing use, depending on how the labour-machinery axis is organised. Instead, there are three manufacturing philosophies which could inform a company's deployment of FMS. Further, pursuit of the gains associated with one philosophy at the expense of both of the other two carries opportunity costs which could outweigh the advantages obtained. (Diagram 1.1 represents the types of costs and benefits which arise from pursuing the different philosophies.) Thus, contrary to what Jaikumar implies, there are limits to the profitable pursuit of flexible ends with FMS.

Diagram 1.1: Relationship between the advantages of "Just-in-Time"; "Flexible Manufacturing"; and "Scientific Management"



Direction of arrows indicate the types of economic advantages that are gained as companies move towards one or other of the manufacturing strategies

In summary, Jaikumar's report of the relative merits of the deployments of FMS in firms in America and Japan appears to be contradictory in places. It has been reported that the general manufacturing success of Japanese firms appears to be linked to their Just-in-Time philosophy. It has been argued here that Just-in-Time could provide a third set of principles or philosophy for the deployment of FMS in addition to Jaikumar's "Scientific Management" and "Flexible Manufacturing". The financial gains of each sometimes overlap but are often mutually exclusive. Pursuit of flexibility, therefore, carries opportunity costs which could outweigh any benefits. As a consequence, it would be incorrect to argue that the benefits that accrue from the installation of FMS can be read, unproblematically from a single or dominant rationality in some notional configuration.

1.3 (b) The Economic Context of the Introduction of FMS: The Genesis of an Era of Flexible Production?

Even if "Flexible Manufacturing" was not the only philosophy embodied in FMS systems it would still be possible to sustain an argument that flexible deployment was the best use of FMS if the general economic conditions favoured the realisation of flexible ends. Jaikumar argues that they do. His argument about the general economic conditions and their present compatibility with flexible deployment of FMS implies a theory of the long term trajectory of industrialized economies. In effect, he describes what forms of work organisation were viable in the past and he details the changes that have to take place to ensure a firm's economic viability in the future. He also offers an explanation of the factors that drive the transformation from the past through the present to the future. If the best use of FMS is to be read from general economic developments it is necessary to evaluate Jaikumar's thesis on the general movement of the economy and compare it with others on the same subject.

Jaikumar argues that, historically, most production costs have been variable and largely constituted of the wages and salaries of labour. Fixed costs, by contrast, were low. The firms that rose to a position of dominance were those which were successful in reducing the variable element of their expenditure. The source of this advantage was, first, work reorganisation in the form of "Scientific Management" and subsequently the introduction of machinery. This gave the innovating firms a price advantage over their rivals. Although not explicitly stated by Jaikumar, it must be presumed that the markets were of a sufficient size to absorb

the increased volume of the type of goods that were manufactured.

Jaikumar goes on to argue that the labour displacement which has already taken place has changed the whole economics of manufacture. This has created a new route by which firms will come to dominate production. The majority of costs are now comprised of fixed capital. The most successful firms will be those that succeed in using labour to exploit the flexibility of production systems such as FMS and add the greatest value to each individual product. Again Jaikumar does not state explicitly that markets are available to absorb the new type of goods that will be manufactured. We can only assume that they do exist. It is from his belief in the changed situation that Jaikumar makes his assertion that the most profitable uses of FMS are being precluded by the legacy of "Scientific Management" in cost control.

There are a number of weaknesses and omissions in this part of Jaikumar's argument which renders it inadequate for explaining the most advantageous use of FMS in the current context. Firstly, as Jaikumar relies solely on the changing economics of production to explain the superiority of particular forms of manufacture he fails to explain why there are corresponding shifts in demand to accommodate such dramatic changes in production. Secondly, in discussing the economics of production he fails to give attention to such factors as local labour markets or industrial and sectoral contingencies. For example, companies that are able to recruit staff with programming skills are likely to view the benefits of FMS differently to firms in areas where such skills are in short supply. Similarly, the relative benefits of achieving reductions in labour will be affected by such factors as safety hazards in

production processes. Thirdly, and as was noted above, Jaikumar fails to provide an adequate explanation of the obstacles to a company's recognition of the benefits of the production systems which they install and the impact of this on their initial choice of system. Thus, Jaikumar's argument, when couched as an explanation of the long term trajectory of industrial societies, is at best incomplete. It may be totally incorrect. There are other theories which seek to explain the long term direction of industrial societies. These interpret the economic context, the suitability of production systems to different eras and the motor of change differently to Jaikumar. Three of these theories, "Flexible Specialization", "Labour Process" theory and "Neo-Fordism" will be considered in order to establish whether they provide a better explanation of the economic advantages of different deployments of FMS in the current context.

(i) Flexible Specialization.

The leading advocates of "Flexible Specialization", Piore and Sabel (1984) (see also, Sabel, 1982; Zeitlin and Hirst, 1991) suggest a similar change in the economics of production and propose a similar scenario to that put forward by Jaikumar. In other words, they argue that the long term trajectory is away from large scale production of standardised goods and they advocate a switch to flexible production of a wide range of items for specialist markets. However, in contrast to Jaikumar's thesis, which is concerned with the engineering industry, Piore and Sabel focus on the consumer goods sector.

Piore and Sabel's argument (see also, Sabel and Zeitlin, 1985)

is that at certain historical points or "Industrial Divides" Government initiatives, market opportunities and companies' own perceptions of their relative strengths and weaknesses lead firms to select a particular type of system of manufacture. If that system proves successful the innovating companies will enjoy an economic advantage over their rivals who will then have to adopt similar methods. The system of production which was adopted at the first "Industrial Divide" was what Piore and Sabel have described as "Mass Production". The principles and economics of this are analogous to Jaikumar's description of American companies' utilisation of Scientific Management. That is, "Mass Production" was characterised by large factories where semi-skilled workers were employed on dedicated machinery in the mass manufacture of identical products for mass markets. As consumers discriminated between the goods of different companies on the basis of their price firms sought to gain a competitive advantage over their rivals by reducing the cost of the variable input, namely labour. Although mass production organisation brought economies of scale and reductions in unit costs the items that were manufactured by this method were consumer durables. As these had had high prices vis-a-vis average incomes, the State had to play a role in ensuring that markets were available to absorb the goods produced. Consequently, national Governments' pursued Keynesian demand management policies, provided welfare benefits and protected Trade Union rights in order to create mass markets.

Piore and Sabel (see also, Sabel; 1982) argue that the "Mass Production" system has experienced a crisis in the past 15 - 20 years. This is not simply a consequence of the changing costs of

production. It is also the outcome of changes in markets which has led to a disjuncture between the output from "Mass Production" factories and the types of goods that are being demanded by consumers in advanced industrialized countries. Demand for the standardized goods produced by the "Mass Production" industries has peaked. Consumers are now more discriminating and select products which express their individuality. Falling demand has been accompanied by a competitive threat from international rivals. Developing countries have found it easy to replicate the standardized and unsophisticated "Mass Production" industries and produce the same goods more cheaply by taking advantage of their abundant supply of cheap labour. As a result they have been able to capture markets which were previously supplied by western industries. The threat to industries in the developed world has been accentuated by their own rising costs of production due to: Wage inflation as marginalised immigrant workers have sought equality with their indigenous counterparts; and, destabilisation of international trade because of uncertainty caused by the floating of the dollar and shortages of oil and other raw materials. The net result of this has been to undermine the hegemony of the previously dominant "Mass Production" industries in the developed world and create the conditions for a second "Industrial Divide".

Piore and Sabel entitle one of their concluding chapters: "Possibilities for Prosperity: International Keynesianism and Flexible Specialization." (1984: 251 - 280). In it they outline two possible routes that companies may follow at this juncture of change. The two potential options resemble closely Jaikumar's

description of American and Japanese firms respective uses of FMS. In "International Keynesianism" the central tenet of companies' manufacturing strategies is to seek further marginal improvements in the productivity of labour in the manufacture of standardized items. Companies continue to employ an extensive division of labour and a semi-skilled workforce but seek improvements over existing production facilities through the introduction of new computer technology and advances in telecommunications. These allow companies to locate factories in different nations and obtain greater economies of scale by making each factory responsible for the production of a single part or range of parts. An example of this option is the "World Car" strategy. Piore and Sabel believe that "International Keynesianism" could meet with some success if greater powers were given to international organisations such as the IMF and GATT. These could help to create a worldwide market of consumers for standardized products by performing regulatory exercises comparable to those conducted by national states in the "Mass Production" period.

Piore and Sabel are opposed to this option. They argue in terms that are not inconsistent with Jaikumar's thesis, that this course of development would be an economically inferior one. The potential of its success is undermined by the hidden costs of: labour dissatisfaction with the technical division of labour; high levels of inventory; fluctuations in consumer demand; and, international instability which international regulatory agencies are unlikely to be able to remedy. Piore and Sabel's preferred option is "Flexible Specialization". The form which they hope that this will take is a community of small workshops collaborating with

one another to ensure satisfaction of the increasingly differentiated market. The central economic logic of these workshops is analogous to Jaikumar's report of Japanese firms' deployment of FMS. Highly skilled workers are employed to enhance the value of output from the general purpose machinery by manufacturing a wide range of specialised goods in limited numbers. When markets are satisfied the machinery is turned to some other production objective. There would still be a role for the State in such a regime but their interventions would take a qualitatively different form to earlier periods. Government policies would not be directed towards demand management as in the "Mass Production" era. Instead they should aim to protect the continued existence of the small workshops essential for "Flexible Specialization" by ensuring that "market transactions do not permanently advantage one group of traders - and thus undermine the balance of wealth and power that makes possible a community of producers" (Piore and Sabel, 1984: 305).

In presenting a more detailed analysis of society as a whole Piore and Sabel do manage to fill in some of the gaps in Jaikumar's account and still arrive at similar conclusions. Conclusions that suggest that the most viable use of FMS is the manufacture of a wide range of parts in small numbers. Their most notable addition is to describe the changes in markets that accompany changes in production. There are, however, a number of weaknesses in Piore and Sabel's argument which undermine the validity of their conclusions. Firstly, it is questionable whether a new regime is arising. Williams et al (1987) raise doubts about one of Piore and Sabel's starting premises by challenging whether demand for mass produced

goods such as televisions and cars have peaked. If this is not the case the large scale industries are not on the precipice of inevitable decline and further expansion may be possible on the basis of "Mass Production" informed economic logic. However, even if manufacturing industries catering for consumer markets were to be experiencing change to more flexible production, would it be correct to generalise a new regime on the basis of the adoption of new principles and techniques in a single sector? Some industries or sectors may experience change in the opposite or other directions. As Walker (1989) has argued qualitatively different - and more advanced - forms of work organisation have existed in chemicals, electricity and other branches of industry alongside so called "Mass Production" manufacturing and Piore and Sabel have not used the introduction of these systems to infer the genesis of a new regime (cf, Blauner, 1964).

Secondly, even if the present does mark the inception of a new regime, the current economic superiority of "Flexible Specialization" appears to be extremely fragile and less pervasive than its advocates imply. Flexible production systems are expensive; more expensive than dedicated systems. This necessitates that a high initial fixed cost is embodied in each unit of production (Boyer, 1987). The burden of these initial costs will multiply quickly if companies have purchased extra capacity in the hope of manufacturing new products for markets that do not materialise. In situations where companies have excess capacity any markets will appear attractive including those that are demanding standardized items. At least some companies, or even whole industries, may find that markets for standardized goods offer a

more viable option at particular points in time. Thirdly, the contours of "Flexible Specialization" regimes are unclear. As Wood (1989; 27) points out it is difficult to envisage the logistics of the market under "Flexible Specialization" where consumers would presumably have several "fittings" to ensure that each and every product they purchased matched their individual needs.

A final weakness in the scenario of "Flexible Specialization" is that the strength of political forces that may oppose change tends to be understated. The large scale factories of the "Mass Production" era did not develop simply as a method for satisfying the demands made for mass produced goods by a population of non-discerning consumers. A precondition of their existence was that they could make profits for their owners. The pursuit of this objective gave rise to highly differentiated business organisations. These employed both a hierarchy of executives and managers who exercise a great deal of power and influence and, in the instance of Britain, a shopfloor workforce enjoying different degrees of autonomy over their immediate work situation. Advocates of "Flexible Specialization" do not make clear how the amorphous mass of disorganised consumer interests will be translated into a force that can erode the power of company executives or even facilitate autonomous work conditions for all shopfloor workers. The pattern of recent industrial change suggests that existing interests are being protected. Boyer (1987) reports that recent movements towards smaller plant size has been accompanied by financial/ ownership concentration. It is also difficult to see why and how relationships within the firm should change to the extent that Piore and Sabel advocate. Even if highly differentiated

markets are being embraced and cultivated by producers some mundane tasks such as loading/ unloading of work pieces, swarf removal and other cleaning exercises will still have to be performed with advanced multi-purpose systems. There is no reason to believe that employers will stop allocating these tasks to cheap, unskilled operatives. These unskilled workers could co-exist with more highly skilled programmer-operators. Contrary to what Piore and Sabel imply the economic principles of "Flexible Specialization" and "Mass Production", and the accompanying forms of work organisation (Kern and Schuman, 1987), may co-exist harmoniously within the same company.

In summary, Piore and Sabel offer a perspective on the development of society that compares with Jaikumar's account of the changing economics of manufacturing. They share with Jaikumar a view that rigid production systems that manufacture goods in large volumes are no longer economically viable. Whilst they do not discuss FMS directly, it is possible to extrapolate from Piore and Sabel's advocacy of "Flexible Specialization" ideas that are parallel to Jaikumar's support of flexible deployment of FMS. Both argue the need for multi-skilled workpeople, employed on multi-purpose machinery, producing a wide range of goods.

Piore and Sabel's account offers improvements to Jaikumar's thesis as they address the issue of market changes. However, Piore and Sabel, like Jaikumar, tend to ignore a range of social, economic and political factors. Their portrayal of industrial change is, thus, incomplete and does not suggest an exhaustive account of the potentially viable deployments of FMS.

There are other theories of long term trajectories which are

better equipped to recognise both the persistence of "Mass Production" type of deployments of computer based systems such as FMS and the vested political relationships which support them. These are the marxist positions of (a) "Labour Process" theory and (b) "Neo-Fordism" which will now be considered.

(ii) Labour Process Theory (5).

Although "Labour Process" theory has its origins in Marx's "Capital" (1954) it was "rediscovered" by Braverman (1974) and has found subsequent expression in Zimbalist (1979), Shaiken (1984) and Armstrong (1988) amongst others. It's explanation of long term technical and industrial change is located in the wider patterns of ownership and control of industry. Braverman recognises profit as the lifeblood of an economy organised around capitalist patterns of ownership. He follows Marx in viewing workers as both the source of, and the threat to, profit (6). On the one hand workers manufacture items of value from which profit is derived; on the other, they are disaffected with their work because its direction by others prevents expression of their natural creativity. The development and purchase of work technologies in capitalist societies follows a path which allows employers to increase the efficiency of labour which is the only truly productive force and, thus, the source of profit. The work technology also embodies capital's need to exercise control over their workforce and counter any resistance to work.

These twin needs gave rise to Scientific Management. The subdivision of work allowed employers to realise the financial benefits of the division of labour that were articulated by Adam

Smith and Charles Babbage. Workers become more productive because of their increased dexterity in a limited range of tasks and because they spend less time in preparations between work stages (Smith, 1937). Employers are also able to save money by only paying premium rates to the limited number of workers who were given sole responsibility for all of the skilled tasks in the reconstituted work process (Babbage, 1971). Scientific Management also afforded employers control over their workforce by taking the responsibility of conception of how a job should be performed away from the shopfloor and locating it in a separate planning division. Workers deprived of the right to determine how they carried out a job had only to follow the highly detailed instructions of others.

Braverman argues that the drive for profit in capitalist economies has led to a concentration of ownership, development of large corporations and a movement from competitive to monopoly capitalism. The natural successor to Scientific Management in the period of monopoly capitalism is Henry Ford's development of mechanised production systems. This not only increased the productivity of workers but also subjected them to greater control as the machine paced and regulated their actions. The recent integration of computers and machine tools in the development of "intelligent" machines is, Braverman claims, simply an extension of this "Fordist" logic of capitalist development to sectors of the economy where workers' autonomy and skills have hitherto been protected by the low volume of throughput. By inference it may be said that, contrary to the arguments of Jaikumar, the use of FMS to realise the benefits of increasing the productivity of labour - rather than harnessing their creativity to proliferate the range of

goods provided - is not the result of a conflict of manufacturing principles belonging to two different historical periods. It is, instead, the natural resolution of class conflict in the medium and small batch production industries in a society that is dominated by capital.

"Labour Process" theory is useful for drawing attention to the fact that there are sectors of the economy where there may still be great potential for increasing the productivity of labour through the introduction of FMS. Despite this, there are logical flaws in the theory and counter evidence which suggests that deployment of FMS for productivity purposes offers no more of a natural "fit" with modern society than systems introduced to meet flexibility purposes. Firstly, it is questionable whether there is any logical consistency between the examples which Braverman uses to imply the "law" of capitalist development and the pattern of deployment of computer based work systems. There is no reason to see "Fordism" as a natural extension of "Scientific Management". The principles that underpin these systems are different from one another. The most famous exponent of Scientific Management, Frederick Taylor, argued that a number of factors should mediate in the decision of whether or not to sub-divide a job to obtain economies. These included ensuring that each worker was fully employed for the duration of the working week even when this resulted in a combination of tasks which could otherwise be separated. (See Kelly, 1982, for further discussion of this issue.) This is not the case in "Fordism" where sub-divided jobs are locked into dedicated technologies with short cycle times. The difference between Scientific Management and Fordism in principle may be seen in practice by the area of the

economy where each were employed. Taylor's installations were primarily in batch production in engineering machine shops where skilled craftspeople were employed. Ford's installations were in the evolving mass-production industries which employed semi-skilled workers to assemble consumer goods such as cars, bicycles, typewriters and domestic appliances. Further, each system sought to bring improvements to different areas of the work process. Walker (1989) disaggregates the labour process into five dimensions:

"(1) conversion, or the transformation of materials into different forms; (2) assembly, or the combination of parts; (3) transfer, or the movement of materials from one work station to another; (4) integration, or the coordination of various sub-processes in complex production systems; [and] (5) regulation, or the self direction and correction of machine performance." (Walker, 1989: 61.)

As Walker points out, whilst Taylor's most important gains were achieved through intensification in conversion, Ford's significant contribution to productivity was in transfer and integration through the introduction of the assembly line.

Secondly, the internal logic of Braverman's argument is contradictory. Braverman claims to draw his inspiration from Marx. Yet in Marx's economic writings machinery is nothing other than dead labour. It is dependent on the living qualities of workers' labour power to set it in motion. Hence capital cannot exercise the degree of control over workers that Braverman implies (Cressey and MacInnes, 1980: Littler and Salaman, 1982).

Thirdly, the raison d'être of any capitalist enterprise is to make a profit. This is not always best served by deskilling workers. Instead employers may develop strategies (Friedman, 1977;

Edwards, 1979 cf. Jones and Rose, 1983; Rose and Jones, 1985) for rewarding certain groups of employees with a number of privileges. These might include use of discretion as a means of reconciling their employees actions with their own interests of pursuing profits. There is an abundance of empirical evidence that links the ability and desire of companies to pursue profitability by deskill^{ing} workers to a number of other factors; including the presence or otherwise of craft traditions of shopfloor workers, trade union strength and the extent to which shopfloor managers identify with the plight of manual workers (Jones, 1982), a company's markets (Wilson and Buchannan, 1988) and national variations in the extent to which a division of labour has existed between technicians and operatives in the past (Sorge et al, 1983; Scott, 1987). Thus, there are examples of the introduction of FMS systems that do allow workers to exercise a wide range of skills (Jones and Scott, 1986; Kelley, 1989).

In summary, whilst labour process theory may draw our attention to a viable rationale for utilisations of FMS that seek to reduce labour in areas which were previously labour intensive it is unable to explain systems which allow workers to exercise a wide range of skills. In this, its strengths and weaknesses are the exact opposite of those of Jaikumar and, to a lesser extent, Piore and Sabel. It would therefore be unwise to portray the use of FMS to gain an economic advantage by deskill^{ing} workers as some natural continuation of the long term nomological trends that are present in capitalist societies. The final thesis of "Neo-Fordism" assimilates some of the stronger points of both "Labour Process" theory and "Flexible Specialization". It is this thesis that we now

consider.

(iii) Neo-Fordism

The French regulationist writers (See Palliox, 1975; Aglietta, 1979) who pioneered the analysis of "Neo-Fordism" (7) also draw on Marx's theories to explain the pattern of technical change but: (a) put greater emphasis on the pursuit of surplus value than do Labour Process theorists and less stress on the need for control of the workforce; and (b) incorporate an acknowledgement of the regulatory mechanisms that were recognised by the "Flexible Specialization" theorists. In Aglietta's version of the theory of "Neo-Fordism", stages of capitalist development may be classified by: the sector of the economy which is experiencing growth; the form of exploitation which is dominant; the type of surplus value which is extracted; and, most notably for our purposes, the form of labour process. As in "Labour Process" theory changes in these areas are driven by the search for profit which stems from capitalist patterns of ownership.

Aglietta describes the early phase of capitalist development as the "extensive" accumulation regime. In this period production relied heavily on the skills and efforts of workers. The primary form of exploitation was the extraction of absolute surplus value, ie, realising and increasing profits by getting people to work harder or more productively without increased assistance from mechanical means. At this time "department one" of the economy, the capital goods sector, was expanded as countries underwent industrialisation. Periods of accumulation are marked by those stable times when production capacity does not exceed consumption.

Change subsequently comes about because production output, which is expanded under the search for profit, finally outstrips customers' desires or capacity to purchase. The initial period of accumulation was brought to an end because the market for capital goods had been satisfied. Further expansion could have taken place if the unexploited "department two" of the economy, the consumer goods sector, had been developed. However, there was not a consumer market for the products such as motor cars and other large durable products. The crisis was resolved following the establishment of regulatory mechanisms (such as the development of the Keynesian welfare state) which ensured that there was a mass of consumers able to purchase the products of the new industries in the developing "department two". The next period of expansion, Aglietta's "intensive" accumulation regime, then ensued. Fordist production systems were introduced, mainly into "department two" of the economy, and this facilitated capital's realisation of profit from relative surplus value, ie, a rise in income that is due to increasing the output of workers by a development in mechanisation rather than from an increase in workers' efforts.

The course of development of work systems in this scenario is compatible with the claims of "Labour Process" theorists. Capitalist owners seek to increase the productivity of the labour that is employed in order to increase profits. This leads to the refinement of work techniques and the development of machinery and a shift from labour intensive methods to capital intensive "Fordist" ones.

Aglietta argues that the owners of capital did not increase their percentage share of what was produced in the course of the

"intensive" accumulation regime. Nonetheless, they did obtain rises in aggregate profits because markets were expanding constantly as growing numbers of the population could afford to purchase consumer durables. However, a crisis ensued when the expansion of markets reached its limit and capital could no longer rely on increased output to protect their profitability. Capital was unable to reduce their costs by cutting its labour bill. The strong trade unions that had grown out of the employment of an amorphous mass of semi-skilled workers at the large, single site, "Fordist" factories would have resisted such a move. Indeed, Capital its costs rising as its contribution to State provision of welfare and other collective services increased. The outcome was stagnation and decline.

The societal level of Aglietta's analysis means that as with the "Flexible Specialization" theorists the potential resolution of the current crisis is dependent on many factors. These include: commodification - ie, privatisation - of social services so that their growth can be regulated by the market; State regulation of investment and incomes to ensure comparability and proportionate growth between the different departments; and a period of devalorisation of capital to recreate the opportunities for profitable production. Most importantly for our purposes it would also involve the establishment of "Neo-Fordism" in the production sphere. This could entail a number of changes. Capital link-ups and telecommunications could be used to decentralise production to a number of different plants as a means of overcoming the militancy of the collective worker. Computerised systems such as FMS could be used in both mass production and batch production to eliminate some

work processes and also to overcome capital's dependency on skilled labour in the latter. However, as Aglietta follows the argument espoused by Marx in "Capital", the underlying principle in any reorganisation of work systems in both mass production and batch production is to increase the productivity and output per unit of labour.

Despite the fact that this theory is able to explain the application of computerised systems to different sectors, it too suffers from a number of weaknesses. Firstly, some aspects have been refuted by historical developments. For example, national states have tended to draw back from regulation of economic activity such as income levels and investments. Secondly, like Piore and Sabel, Aglietta has extrapolated changes in work organisation and used this to generalise movements between whole societal formations or "accumulation regimes". Any changes in the sector where surplus value may be extracted or alterations to the form of state activity are all supposed to have arisen because there are no further opportunities for enhancement of production performance by existing "Fordist" methods. Thirdly, as Boyer (1987) points out, there is no reason to believe that transition to a different regime will necessarily continue the economic principles of the regime that it has succeeded. In his modification of Aglietta's stance Boyer argues that there is only a probability that the application of artificial intelligence to new production systems will be used to increase the productivity of labour in long run manufacture of parts. He also contends that as Capital's overriding concern is to make a profit, there will be a number of different deployments. The form of any new production system will

be influenced by sectoral and national contingencies on the opportunities for profitable production. Computerised configurations could be introduced to pursue the principles of "Neo-Fordism", "Flexible Specialization" or other manufacturing objectives.

It should be clear from the preceding discussion that Boyer's suggestion of alternative paths of development and production principles in different sectors and national settings is more akin to the reality which it seeks to explain than any of the other theories of trajectories including that proposed by Jaikumar. All of these tend to emphasise only one possible route to future economic prosperity: either further restrictions on labour as a means of increasing productivity; or, the lifting of restrictions as a means of increasing variety of output. There are, however, two salient weaknesses in Boyer's account. These are shortcomings which he shares with all of the theories already discussed and they serve to render his, and the other, arguments inadequate for explaining the problems confronting this thesis.

Firstly, all of the theories of trajectories tend to be expressed at a level of abstraction that is inapplicable when explaining the economic behaviour of most firms. Whilst all of the authors imply the strengths of systems over the long term, companies assess the value of their investments over the short to medium term. The investments in the FMS systems that are considered by this study were amortised over periods of between two and twelve years.

Secondly, all of the theorists assume that some form of Mass Production system was the dominant method of production in the

past. This must be questioned, at least with regard to the types of production techniques that have been deployed in Britain. No more than 7% of the workforce have been employed in mass production factories (Gallagher; 1980; 76) and less than half of manual workers in such factories have been engaged on mass production work (Wild, 1974: 535). It is, therefore, not surprising that 80% of engineering components are machined in batches of less than 1,000 (Littler and Salaman, 1984; 90). This situation makes it difficult to sustain any of the arguments above as they all generalise the future development of the economy on assumptions of the proven merits or exhaustion of a system that has had only limited applicability. This is not to deny that different authors may have identified the strengths of different manufacturing strategies such as "Flexible Manufacturing"/ "Flexible Specialization" or "Mass Production"/ "Fordism". However, it does mean that the financial advantages that accrue to a company when they adopt these strategies must be established by some means other than reference to the theories of long term trajectories discussed here. It is only subsequent to this that it is possible to establish the extent to which organisational factors such as cost controls are leading to the misuse of work techniques and systems.

1.3 (c) Summary.

In summary a provisional assessment of Jaikumar's claims that systems of cost control contribute to the misuse of FMS shows that his arguments imply a set of dominant manufacturing principles embodied in FMS and/ or predictions about the long term economic trajectory of society. A detailed critique of both assumptions has

shown them to be inadequate for establishing the most viable use of FMS. But this must be done before an assumption of the impact of accounting practices on the deployment of FMS is possible. This issue will be returned to in Chapter Three.

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1.4 The Impact of Pre-investment justifications on the utilisation of FMS?

Before this introductory chapter is concluded one other part of Jaikumar's argument will be considered; that is his failure to treat the deployment of FMS as part of a process of technical change and to investigate the earlier stages in that process. Jaikumar's argument is, that companies have introduced FMS systems that are best suited to the production of a wide range of goods in small batches. The legacy of "Scientific Management" inherent in American firms' structures and cost control methods results in FMS being used for large batch production of a limited range of goods. Jaikumar believes that a comparison between Japanese and American companies suggests that the American firms' deployments of FMS are not financially viable in the long term.

But this argument leaves unanswered the question of why American companies selected FMS in the first instance? Was it to machine a wide or limited variety of parts? A number of other authors (Avlantis and Parkinson, 1981; Bessant and Haywood, 1985) have argued that a limited range of ten parts, which were machined on systems in American firms in Jaikumar's study, does constitute a financially viable form of production with FMS. It may also be asked whether flexible or high productivity aspirations were expressed in pre-investment justifications? As Jaikumar (1984: 20 - 21) himself acknowledges, biases also exist in pre-investment appraisals. Yet he fails to explain what the consequences are, for the deployment of FMS and post-installation cost control, of a scenario projected in either biased or representative pre-investment justifications. Unless Jaikumar is claiming systems are

introduced at random, the eventual pattern of deployment of FMS cannot be understood by simply focusing on the influence of cost control. Thus, Chapter Four will investigate the potential impact of weaknesses in both pre-investment financial evaluations and cost control on the eventual deployment of FMS.

1.5 Summary, conclusion and outline of remainder of thesis.

This introductory chapter has explained that the objective of this study is to examine the impact of accounting techniques on the deployment of FMS at firms in Britain. The impetus for this study came from work conducted by Jaikumar (1984; 1986). He reports that FMS in American firms are used for less flexible objectives than their Japanese counterparts. This, he argues, is to the detriment of American companies. He believes that such an undesirable outcome occurs because of continued presence of the anachronistic philosophy of "Scientific Management" and its manifestation in the cost controls of American firms.

In the critical evaluation that has been provided of Jaikumar's thesis, a number of weaknesses have been identified. These must be remedied before it is possible to assess the impact of cost control on the deployment of FMS systems in British firms. The particular issues that require clarification are as follows. Firstly, is it possible for accountants to apply an inappropriate analysis to the evaluation and monitoring of an engineering system and still retain their position when their actions are detrimental to a firms interests? Secondly, how can the financial merits and best use of FMS be established other than by reference to the coincidence of the systems' implicit rationality with the emergent

economic order? Thirdly, what influence do the biases in pre-investment justification have on the eventual pattern of FMS, and are the biases in cost control additional to these? The clarification of these issues in the first half of this thesis will provide a framework from which the findings of this study may be analysed in the second half of the dissertation. Chapter Two provides a sociological account of the relationship between engineers and accountants in British firms, and theorizes the extent to which accountants are able to impose an inappropriate analysis on engineers' proposals of new systems. Chapter Three considers the economic viability of particular types of deployment of different FMS systems from within the context of the production systems that preceded them and the opportunity cost of not pursuing other manufacturing alternatives. Chapter Four reports in detail the structure of pre-investment justification and cost control practices so that their divergence from the contours of different deployments of FMS are apparent. This chapter also uses the framework developed in the first part of this thesis to evaluate the existing evidence on the relationship between accounting practices and the deployment of FMS.

The findings of this study are reported in the second half of this dissertation. Chapter Five describes how the respective positions of accountants and engineers, discussed in Chapter Two, materialise in the capital sanctioning route. This will illustrate the nature of engineers' opportunity to influence accounting practices to prevent the misuse of engineering systems. Chapter Six discusses the stages of selection and financial justification of FMS in the process of technical change. The findings reported in

this chapter illustrates that different patterns of deployment of FMS can be perceived partly as an intended consequence of conscious decisions taken prior to a system's installation. Chapter Seven looks at the extent to which post installation cost control systems were able to measure the anticipated benefits of FMS and the outcome of any failure to do so. Chapter Eight concludes the discussion. The main findings are as follows.

- * Companies in Britain that have introduced FMS have selected their systems for one of three reasons: "To increase machine utilisation"; "to reduce the value of inventories carried"; and "to respond to demand for an increasing range of parts".

- * These different motivations for selecting FMS demonstrate that whatever is the long term trajectory of the economy, there is evidence of a number of different and counterposing tendencies. That is to say, local situations allow different firms to pursue different forms of profitable production with FMS.

- * Accountants do not impose their analysis on FMS. Engineers conduct the initial pre-investment justification and play an important role in articulating the standards by which FMS systems are assessed.

- * There is a strong strand of continuity running through the whole process of technical change at each company. Companies were largely successful in justifying and monitoring their respective FMS systems in accord with their stated manufacturing objectives.

- * Whilst accounting practices do not articulate a complete profile of certain deployments of FMS they do, nonetheless, help to promote the continuity alluded to above. The claims made in the pre-investment justification of what a system is able to produce is

transferred to the cost monitoring apparatus of flexible budgets and provides the standards by which a system is monitored.

Footnotes:

(1) In contrast to Jaikumar who claims that further labour savings are minimal, British authors have claimed that further labour savings may be quite large. For example, claims about the amount of labour reductions that will follow the introduction of FMS varies from between 10% (Ingersoll Engineers, 1982) to 60% (Department of Industry: National Engineering Laboratory, 1978).

(2) Jaikumar does not use the term "Flexible Manufacturing". It is used here for the sake of convenience to describe the form of work principles and organisation that he counterposes to "Scientific Management".

(3) Jaikumar presents a rather limited view of "Scientific Management". He tends to perceive it as equivalent to standard forms of mass production organisation. That is, it is concerned with minimising unit costs by the employment of semi-skilled workers to produce the maximum number of parts with highly productive machines that are dedicated to a single use (even if they are not designed for that purpose). Thus, whilst there are differences between the two (see p. 23 of this thesis) the term "Mass Production" may be read as interchangeable with "Scientific Management" when Jaikumar's ideas are being discussed.

(4) Another critic of cost control, Robert Kaplan (1983: 693) suggests that these could include the speed of introduction and delivery of new products to customer specification.

(5) "Fordism" is used in different ways by "Labour Process" and "Neo-Fordism" theorists. Writers in the Labour Process tradition use the term to describe the work system associated with Henry Ford. That is the organisation of dedicated single purpose machinery around a mechanised flow line. The regulationists such as Aglietta use "Fordism" to describe an era in society when this production form co-existed with mass consumption and a national State dedicated to reconciling production and consumption with one another. Aglietta's use of "Fordism" is, thus, comparable to Piore and Sabel's notion of "Mass Production". The reader should be sensitive to the different uses of the term "Fordism" and read their different meanings according to the author that is being considered.

(6) The reason why profit is derived from labour is because labour is the only force that is employed in production which is capable of creating more than the value which is expended in its recreation. Thus, for Marx labour value is central to defining the extent and rate of profit. This is different to the everyday notions of profit expressed in monetary values. As Thompson (1978) points out, this does not mean that either set of calculations are

"wrong" or internally illogical. It means simply that attempts to move between the different forms of discourse are laden with problems. Thus, whilst throughout this dissertation reference will be made to sociological and political theories which draw on Marxism, these are accepted as having validity per se. No attempt will be made to use marxist value categories to assess the validity of the calculations made by the firms surveyed. This study is primarily concerned with the limitations of current accounting practices when conducting the calculations that the firms themselves make.

(7) The term "Neo-Fordism" has often been used to describe production forms discussed by writers from a different theoretical background. "Neo-Fordism" is sometimes used to refer to the Flexible Specialization theorists (See: Sabel, 1982; Piore and Sabel, 1984) notions of "International Keynesianism". As I have already discussed the merits of this theory there is no further need for a discussion of this use of "Neo-Fordism". A third use of "Neo-fordism" is that employed by sections of the British left (see Murray, 1985; 1988). However, there is some confusion in their terminology which makes it difficult to delineate between "Neo-Fordism" and "Flexible Specialization" (Scott, 1987; Wood, 1989). As a consequence, it has limited relevance in considering the long term trajectory of industrial societies as being towards either one or other of these two forms of organisation. Therefore, I do not intend to discuss these ideas further.

Chapter Two.

2.1 Introduction.

Chapter One has explained that this research aims to investigate whether the application of biased accounting techniques is preventing FMS systems from being used for the most beneficial of purposes. The extent to which financial criteria may divert an engineering system away from the purposes for which it was initially intended will be dependent on three factors. First, practitioners of accounting must be in a position to conduct an evaluation of engineering systems. Second, accountants must enjoy a position of sufficient influence to override other criteria. What is more that influence must have some basis other than the "truth" in the accounting analysis if the re-direction of engineering system is to the detriment of the firm. Third, accountants must possess the necessary instruments to stop the engineering system from being used for one purpose and then direct it towards another.

This chapter aims to provide a generalised account of the ability of accountants to intervene in the process of technical change. This will provide the means of identifying in the subsequent chapters, the potential for accounting criteria to be deployed to mis-direct FMS systems away from desirable objectives. The Chapter falls into three sections. The first details the relationship between accountants who are responsible for initiating the introduction of new systems and accountants who supervise the application of financial criteria. In the second section theories of accounting are examined for their insights into the extent of "truth" that may exist in the accounting analysis and the source of the accountant's power. This will allow an assessment of the extent

to which accountants' ability to make interventions is linked to the validity of those interventions. If the accountants' analysis only generates "truthful" financial evaluations of the performance of a system a re-orientation of FMS towards a new use as a consequence of that evaluation cannot be considered to be an inappropriate or undesirable outcome. The third section compares the development of cost control techniques in Britain with those pioneered by the Scientific Managers in the USA and uses the latter to highlight the limited knowledge that accountants have of shopfloor processes in Britain. The chapter concludes that, whilst accountants may be in a position of formal superordination in the enterprise, they have limited knowledge of shopfloor processes. Accountants are dependent on engineers for information and this is likely to limit the nature of an accountant's opportunity to direct systems away from the purpose that they were initially introduced to meet.

2.2 Engineers and Accountants as Fractions of Management.

In the course of this century there has been a concentration of industrial production and a general growth in the size of business organisations. For example, the largest 100 firms in Britain produced 40% of manufacturing net output in 1970 compared with only 16% in 1909 (Littler and Salaman, 1984: 32). Thus, by 1978 25% of the people who were employed in manufacturing worked for enterprises that had 20,000 or more employees (*ibid*, see also Hannah, 1976; Prais, 1976; 1981). Transnational ownership and corporate forms of organisation have resulted in the manufacturing facilities of these firms being situated across a number of

different sites, subsidiary companies and even nations. Public flotations have increased the number of people who share in the ownership of these companies. One consequence of these factors is that many owners are no longer able to take direct responsibility for managing their firms. There is recognition by writers from a wide range of political opinions and academic disciplines (for example, Burnham, 1941; cf Galbraith, 1967; cf Wright, 1976; Carchedi, 1977) that the function of managing has been devolved to a range of specialist groups of employees. Rule-governed procedures have generally been instituted into a company's structures to provide guidance for each occupational group when carrying out their responsibilities (1). Two such groups of employees are accountants and engineers. These share in the responsibility of ensuring that the company purchases and deploys effectively new production systems that are able to meet the firm's manufacturing objectives and protect its profitability.

The contribution of Management Accounting to this has been defined as:

"the application of accounting techniques to the provision of information designed to assist all levels of management in planning and controlling the activities of the firm."
(Sizer, 1975: 13. Original emphasis.)

The important tools that are used in this are plans, costs and budgets (see, Hofstede, 1968; 27: Storey, 1983; 150 - 152). The overall plan describes a company's operations for the year. Each operation will be given a cost and the total of the costings will, if all current costs are being charged to products, give the total value of the master budget for the year. This is then sub-divided into constituent budgets of various types - for example, sales,

manufacturing department's budgets, inventory, purchasing and capital. The control function is achieved through each budget as:

"it serves to authorise, or conversely, render illegitimate, certain expenditures and courses of action which do not concur with the official plan." (Storey, 1983; 151.)

The overall objective of the accounting function is to ensure that the firm's planned and actual expenditure is kept at a level which protects a company's profitability.

The "direct practice of engineering" contributes to the management of a company by:

"designing new products and systems, or in supervising their production or operation" (Berthoud and Smith, 1980: 27).

The points in the process of technical change where there is an overlap in the responsibilities of accountants and engineers, and where the allegedly inappropriate techniques are administered by accountants, are the stages of pre-investment justifications and post-installation cost control. The pre-investment justification is the stage when the merits of a proposed new system are evaluated to assess whether the adoption of such a change is likely to bring financial improvements to the company's performance. Engineers tend to be involved in the early stages of the capital sanctioning process and define the parameters of savings in pre-investment justifications; accounting staff are employed in the subsequent corroboration of the existence of these savings and assessment of their impact on the financial performance of the company (Klahorst, 1983: 67). Changes in manufacturing capacities and performance that stem from the introduction of new equipment are then converted back, by accountants, into changes in the expectations of

performance of departments and these changes are reflected in amendments to the budgets that engineers and others are expected to work to. Thus, there is a clear relationship between the calculations performed at the pre-investment justification and post-installation cost control stages.

Accountants and engineers do not only play different roles within the enterprise; they also tend to hold different places within the company's hierarchy. The senior financial staff are often situated close to the apex of a company. For example, McKenna (1978: 14) found instances where the titles and/or functions of "Financial Controller", "Chief Accountant" and "Financial Director" were interchangeable. Also, a growing number of company chairmen (sic) started their careers in accountancy (Stanworth and Giddens, 1974: 86) and the single most common qualification of directors in Britain is membership of the Institute of Chartered Accountants (The Director, January 1965, pp. 87 - 91).

By contrast, engineers are now often situated in a lowly position in a company's hierarchy. Whilst engineers are often involved in the management of projects and processes (New, 1976: 10; Berthoud and Smith, 1980; Scott et al., 1991: 22) they do not generally have other managers or even line supervisors reporting to them (Venning, 1975: 62-3; Whalley, 1986: 92; Smith, 1990). It is also unusual for them to rise to board level. Monck (1954) reported that one-third of the companies in his sample did not have a technically qualified director.

There is evidence that the different locations of the different functional groups influences the weight given to their respective analyses in the decision-making process. In the higher

echelons of a company the emphasis is on financial control (Armstrong, 1987a: 415) and this allows accountants to define as invalid engineering considerations when they do not conform with accounting criteria. This is illustrated vividly by the research of T.C. Jones (1990a). He reports an accountant's description of his interaction with engineers in the following way:

"The engineers are designing an all-singing, all-dancing machine - the best that they can design. Very often they don't look at the financial side of things. Their job is to design a damn good machine - that's what they want to do. They get upset when we come back and say "this machine is too expensive - can you cut down this? Can you select a cheaper material?" They get very upset." (1990a: 280)

Similarly, Kornach (1966) reports that financial criteria have percolated down into engineering and that "calculation of costs is fundamental in engineering and overdominates all other calculations".

In summary, engineers and accountants are two occupational groups involved in the management of companies. Both have the opportunity to intervene in the process of technical change. Engineers have the initial responsibility for proposing methods of how a firm should manufacture its products. Accountants have the responsibility for ensuring that the contours of such proposals are confined within the financial parameters that protect a company's profitability. Thus, the engineers' conduct of their functions tends to be proactive and precede those of the accountant who react to the engineers' proposals. The accountants' tend to occupy a position of greater stature than that held by engineers in the firm. As a result, accounting criteria may be used to precipitate revisions in engineering considerations. For example, accounting

criteria are used to decide whether or not to purchase an FMS system and whether its current deployment is financially acceptable. The bases of accountant's greater stature, the validity of the accounting analysis, and why it might diverge from the logic embodied in engineering systems such as FMS, will be considered in the next section.

2.3 Theories of Accounting.

Critics of accounting argue that current applications of pre-investment appraisals and post-installation cost controls (see Chapter Four below) fail to produce the best possible outcome for companies that are considering, or have succeeded in, introducing FMS. Yet no explanation is offered of why accountants' failure to select the most profitable option does not lead to a challenge to their authority. It is, therefore, necessary to investigate whether any theory of accounting can explain this issue. Loft (1989) suggests that there are variants of four theories of accounting: The "Conventional" or "Traditional" view; the "Changing Cost of Accounting Information" stance, which is subsumed below under the title of "The American Engineering-Accounting Discord School"; the "Genealogical" analysis; and, the "Labour Process" perspective. Each viewpoint will be examined in turn as a means of establishing its potential to explain the extent of "truth" in the accounting analysis; the reasons for any divergence in analyses between accountants and other groups of personnel such as engineers; and, the bases of the accountants' apparent power which allegedly allows them to impose an inappropriate analysis on the evaluation and monitoring of an engineering system.

(i) Traditional Perspective.

The Conventional or Traditional view of accounting (see, for example, Stacey, 1954) parallels the tradition in Sociology which originated from Emile Durkheim (1933) and found subsequent manifestation in writers such as Daniel Bell (1974). From this perspective accounting, like any other discipline, is viewed as a set of neutral techniques based on scientific principles. These are administered by accountants who are dispassionate and objective practitioners articulating the collective interests of the organisation. The constituent population of any enterprise co-exist harmoniously with one another and share in its single rationality. The relative position of accountants vis-a-vis other groups is determined by the degree of abstraction and thus general applicability of the different groups' respective analyses. The basis of accountant's authority over other groups in the firm is their ability to develop and employ techniques which facilitate the financial well-being of the company. Therefore, the history of accounting may be viewed as the ontological development of practices of increasing complexity and applicability in response to and reflective of the corresponding developments in the company and society as a whole.

The ability of this perspective to explain the issues addressed in this dissertation is questionable. The traditionalists imply that all of the systems of knowledge employed in a company run parallel to one another as they are all predicated on a single rationality. Yet the potential divergence between "productivity" and "flexibility" goals that were discussed in Chapter One illustrates that this is a contentious issue. (See also Dermer and

Lucas, 1986: 476; Cooper and Robson, 1990: 371.) The traditionalists perceive this and other conflicts as mere pathological aberrations that will be resolved because of the essential validity and increasing applicability of the disciplines. However, this denies the possibility that the origins of conflicts may be structured into patterns of ownership, control and administration of production, which leads to the various groups that exist within the enterprise having different interests (Hopper et al., 1987: 440). It also ignores the potentiality that the most powerful groups will institute structures and practices that present their own interests as tantamount to the interests of the enterprise more generally. Thus, any influence that accountants enjoy in decision making structures may be related to their allegiance with the most powerful groups rather than being a simple product of their technical competence (Cooper and Robson 1990: 371; Willmott, 1990: 315 - 6; and, see also "Labour Process" theory, below).

The traditionalists' failure to address the competing interests that might exist means that they legitimize rather than explain the pursuit of a specific set of economic values and goals and the subsequent economic decisions and they marginalise others (MacIntosh, 1990: 153 - 4). Moreover, as the "Changing Cost of Accounting Information" perspective demonstrates (see directly below) accounting techniques did not develop along a unidirectional path from the least complex to the most sophisticated.

(ii) The American "Engineering-Accounting Discord" School.

The idea expressed by these theorists is that accounting

practices are out of time with engineering changes. The first set of theorists (Kaplan, 1986; Jaikumar, 1984; 1986) suggest that there is some type of "accounting lag" (Kaplan, 1986: 199) between the development of new engineering systems and changes to the accounting analysis. As Jaikumar's claims have already been discussed in some detail and the emphasis shifts in Kaplan's ideas this part of the discussion will concentrate on the second set of arguments, the "Changing Cost of Accounting Information" (Johnson and Kaplan, 1987; Kaplan, 1988).

These writers suggest that there has actually been a regression in the sophistication of accounting techniques. Thus they argue against the unidirectional and progressive development of accounting knowledge implied by the traditional viewpoint. Johnson and Kaplan recognise that accounting is intended to provide information about the firm but they do not believe that the complexity of its analysis has stayed in step with the increased complexity of the organisation. They argue that accounting is subjected to a number of pressures, not least the financial cost of generating information. As organisations have developed, accounting has been expected to perform an increasing number of functions. The consequence of the concurrent demands for more financial information and the conflicting restrictions on the development of accounting has been the evolution of a caricatured system that may be sufficiently refined to meet one objective but is applied to many. Thus, there is the divergence of accounting from the reality that it seeks to explain. The historical development of accounting techniques are discussed in some detail below. However, for the purpose of elaborating on Johnson and Kaplan's theory, their

discussion of the developments of different uses of "standards" in accounting will be considered briefly.

Johnson and Kaplan (1987: pp 47 et seq. and 125 - 7) argue that there have been three developments in the use of standards in costing. The first of these was when standards were developed as a management tool to control production. This innovation came from the Scientific Management school - see section 2.4 below - who dissected the production process to determine the appropriate levels of efficiency or standards of output for individual workers in a given industry. The second development, variance analysis, was also concerned with control of production and again originated from practitioners of Scientific Management such as Gantt, Longmuir, Harrison and Emerson. This involved the formulation of equations for determining the actual degree of variances in output and contingent financial performance of production departments from the initial standards set by the Scientific Managers. The purpose of this was to allow companies to differentiate between increases in expenditure that were attributable to controllable conditions and those which management could do nothing about. At this time any costs (ie, overheads) that were incurred by the firm outside of the production process could either be apportioned in a general way to each unit of the single type of product manufactured or would be meticulously traced back to their source of origin by the Scientific Managers.

Subsequent to these early developments, companies have expanded in size and adopted a multi-divisional form of organisation. The new corporation now produces a wide range of goods, often within the same division. Government agencies demand

that the corporations report their assets for tax and other purposes. In this changed situation a third use of standards, inventory costing, has been developed by accountants as a simple method of evaluating part processed goods. When calculating the value of inventory amongst the company's assets accountants have simply multiplied the volume of goods at a given stage in the production process by a standard value. That value is believed to represent the cost of the work that had been carried out on the product up to that point and includes a standard proportion of overheads. However, as most companies now produce a range of goods, overhead costs are not incurred in a standard way, but bear a relationship to the complexity of the process of their individual production.

Despite this inadequacy, the same information is used to decide the relative, financial, efficiency of different operations. Production decisions are then made on the basis of this false information (Johnson and Kaplan, 1987; 127 et seq.). Johnson and Kaplan believe that the reason why the Scientific Manager's practice of tracing all costs to their original source has ceased may be due in part to "their high cost-to-benefit ratio". However, they attribute the ascendancy of inventory costing to the need for companies to provide information for outside bodies for tax and investment purposes.

Johnson and Kaplan go on to argue that these problems are often accentuated by the techniques that are now used to control and motivate company personnel. Higher managers examine the Return on Investment (ROI) that particular departments earn, which embody the false information described above, and then use the allocation

of departmental budgets and promotions as a means of disciplining and rewarding personnel. As these assessments are made over a limited period they encourage departmental managers to pursue short-term goals. This discourages the use of any technique of production, such as flexible usage of FMS, that requires some foresight. Johnson and Kaplan argue that the use of these inadequate practices are being perpetuated by staff at University departments through their teachings and writing of accounting text books. Their proposed solution to a single and inadequate, all purpose costing system is to have several different systems; each of which is directed to a specific purpose such as overhead allocation or control of shopfloor activities (see also, Kaplan, 1988).

The merit of this theory is that it serves to illustrate that there is not a single rationality within a company. There is clearly the potential for conflict between different fractions of management such as engineers and accountants. Johnson and Kaplan's thesis also offers a way of filling the gaps in Jaikumar's argument. As was noted in Chapter One, Jaikumar failed to explain fully how flexible systems come to be introduced into companies where the philosophy of Scientific Management pervades all activities. In Johnson and Kaplan's argument accountants are able to establish a power base by offering cheap methods of financial control and of conversing with outside bodies. These methods, whilst having the appeal of cheapness, also contain logic which impels companies to produce standardized products. It may be construed from Johnson and Kaplan's writings that engineers who do not subscribe to this logic attempt to introduce different

production systems.

Despite these strengths Johnson and Kaplan's thesis suffers from a number of weaknesses. First, they fail to explain why it is accountants, rather than other groups of personnel, who have developed systems of analysis, albeit inexpensive ones, for control of the production process and for dialogue with outside bodies. Second, they tend to oversimplify the different interests that exist within the company. Conflicts of rationalities are presented as revolving around scenarios advocated by either accountants or engineers. Johnson and Kaplan thus fall into the trap of the conventional approach of legitimating only a limited range of interests and marginalising others. In so doing, they ignore power relationships other than those between accountants and instigators of new systems. This leads to their failure to explain in whose interests accountants are acting when they apply their inadequate analysis to select inappropriate options in preference to others. Perhaps more importantly, they do not follow through the logic of their own argument. If engineers are introducing systems that embrace a non-standardized production rationality, the power of the accounting analysis and its ability to direct systems towards the wrong goals may not be as pervasive as these authors suggest.

(iii) Genealogical Approach

The third perspective of accounting which is considered here is the "Genealogical Approach" (see Loft - 1986; 1988; 1989; Roberts and Scapens 1990). Advocates of this viewpoint derive their inspiration from Foucault's work on punishment and discipline: They perceive accounting as "one of the central disciplinary techniques

in industrial society" (Loft, 1989: 16) with a structure that is analogous to a panopticon. In a panopticon observers are based at the centre with the remainder of the organisation forming concentric circles surrounding them. The centre is divided from other parts of the organisation by frosted windows. As the beam of light is from the outside shining inwards, silhouettes of the outer rings are projected to the benefits of those on the inside. The people situated at the kernel of the organisation are able to view the activities of those in the outer rings but not vice versa. Accounting techniques are perceived as analogous to the panopticon because they bring into vision the full range of activities that go on in the production process. In this Loft (1986, 139: 1988, 6) draws on Braverman's analysis and views accounting as the "parallel activities" which are "a replication of the process of production in paper form before, as, and after it takes place in physical form".

Following Foucault, theorists from the Genealogical Tradition argue that there is a dialectical relationship between power and knowledge. The people in a position of power are able to institute the accounting techniques which generate valid knowledge and this in turn secures their tenure in those positions of power. The initial source of this power is derived from a number of general and/ or historically specific origins. For example, Roberts and Scapens (1990; 107) report that it is the executive boards of organisations that sit in the centre. Loft (1986; 1988), by contrast, discusses the power that accounting systems gives to accountants. She details how the Government's actions in the unusual circumstances of a wartime economy provided an environment

in which accountants rose to a position of authority within the enterprise through the conscious pursuit of a professionalisation project. That is to say, accountants used notions of competence to define their domain and to identify those who were and were not able to practice accounting techniques. Loft says:

"For accounting in business enterprises in the United Kingdom is not simply carried on by a hierarchy of bureaucratic functionaries, but by professional accountants with allegiances to their professional associations as well as to the organisations in which they work. Through their publications, meetings, examination syllabi and other activities these associations play a role in defining and furthering the techniques of accounting, deciding who is competent to practise and in elaborating the discourse. They are clearly closely involved with the creation of management accounting as it is." (Loft, 1986: 140. My emphasis.)

According to Loft, the period that provided the springboard for accountants to advance this project was the First World War. The Government had to find ways of preventing profiteering when the pattern of wartime demand had rendered the market an inadequate mechanism for allocating resources. Wholesale nationalisation or centralised direction of all areas of the economy was considered unacceptable. Instead the method adopted for determining a fair price for goods provided by private factories was by assessment of reasonable costs. These were determined by a comparison between the costs in National Factories and others. Accountants projected themselves forwards to assume responsibility for assessment of these costs.

Loft, in addressing both the conditions external to the firm and the activities of groups of personnel, offers a more adequate explanation than the other approaches discussed so far of how

accountants have risen to a position of authority within the enterprise. Her theory tends to fall down because she follows Braverman in arguing that accounting creates a paper replication of shopfloor activities in the office so that it may exercise control "from the very bottom of the organisation to the uttermost top" (Loft, 1989: 16). - Roberts and Scapens do not use the same argument in this respect and see gaps between what occurs in practice and what is presented on paper. - Yet if this control is so absolute how is it possible to introduce systems that are allegedly incompatible with the logic in pre-investment justifications? Further, the inference of increasing power and influence of accountants based on their increasing knowledge does not allow the scenario that Johnson and Kaplan suggest, ie, that accounting does not generate valid and accurate knowledge which perpetuates the existence of the enterprise. The corollary of this is that, instead of actually cementing the power position of the people at the apex, it could be undermining it.

(iv) Labour Process Approach

The final theory which is considered here is that of the "Labour Process". Its advocates (Hopper et al, 1986; Hopper et al, 1987; Bougen, 1989) draw their inspiration from Harry Braverman's (1974) "Labour and Monopoly Capital". The central tenet of their argument is that the overriding concern of all capitalist organisations is to obtain profit or surplus value (Hopper et al, 1987). Thus, employers treat their workforce who are autonomous beings as simple commodities malleable to the demands of the production process. The alienating effects which this has on

employees presents employers with the problem of how to turn the potential output of labour or labour power, which they purchase from a recalcitrant workforce, into items or commodities that are of value. Accounting has been developed as a means of surveillance and control whenever problems in the production sphere, or some other part of the valorization process, invokes a crisis for capital.

It is, therefore, not possible to perceive accounting as a set of neutral techniques. They are, instead, a set of practical and ideological tools used on behalf of capital and at the expense of oppressed classes to perpetuate capitalist patterns of ownership by extracting surplus value. Consequently, practitioners of accounting are not neutral professionals. Accountants occupy an ambiguous position between the antagonistic classes of capital and labour; they perform some of the functions of capital, but they do not share their objective class position of owning the means of production. Their world view is shaped by this position. The relative standing of accountants and other occupational groups within management depends on their respective abilities to win favourable patronage from capitalist owners by devising strategies that resolve problems which confront employers.

This perspective has much to recommend it. It has the advantage of explaining; how changes in the accounting analysis may be precipitated, the way in which accounting may only represent the interests of some groups, and the nature of some of the unequal power relationships and competing interests that exist within the enterprise. Nonetheless, it too suffers from a number of weaknesses, which undermines its ability to explain the problems

confronting this thesis.

As Loft (1989: 11) remarks, Labour Process theory sees the development of accounting from "primitive cost accounting systems into sophisticated management accounting systems". This suggests an ontology which is often absent as is demonstrated by the research of Johnson and Kaplan (1987). One salient weakness in Labour Process Theory has been highlighted by one of its advocates, Peter Armstrong. Armstrong (1985: 1987a) has remarked that the description of the historical development of accounting controls offered by Labour Process theory often comes close to functionalism, and the traditional perspective discussed above, because accounting techniques are seen to arise as and when capital needs them to resolve a problem at a time of crisis. Further, explanations of the authority of different fractions of management by reference to their administration of given techniques are teleological. Armstrong, in his revision of "Labour Process Theory", seeks to explain the relative position of different fractions of management by an examination of the factors that led to accounting methods of control being adopted by companies and why the application of such methods has been under the supervision of accountants. It is therefore of value to outline Armstrong's (1984a: 1984b: 1985: 1987a: 1987b) refinement of Labour Process theory in some detail.

According to Armstrong, the growth of the corporation and the accompanying societal-wide changes have important implications for the valorization process in capitalist economies. In present times employers have to find ways of: (i) ensuring that operatives work to a satisfactory capacity in the production process even though

they are not under the direct supervision of the owners of corporations; (ii) selling the range of goods that are produced at a price which provides the company with a sufficient level of profitability and to introduce when necessary any innovations in products and processes which protect that profitability; and, (iii) ensuring that other companies observe the rules of the game and protect the continued existence of the capitalist system by maintaining the value of their capital assets at their true worth instead of distributing too much of their revenue in dividends. Armstrong (1987a: 417 - 418) uses Marxian concepts to classify these respective activities as (i) extraction, (ii) realisation, and (iii) allocation of surplus value. The fortunes of different occupational groups in general, and engineers and accountants in particular, have been tied up with their ability to carry out whichever function was of greatest importance to the perpetuation of the enterprise at different points in history.

When capitalist firms were limited in size the creation of goods or increasing the productivity of labour in the creation of goods were of prime importance. Mechanical engineers either ran their own businesses or managed the companies of others as engineering knowledge was important to increasing output/ producing surplus value (Armstrong, 1984b: 106). By contrast, the high profit margins which companies enjoyed rendered insignificant any value that the existing coarse costing methods offered (Armstrong, 1985: 135). When the relevance of engineering to managing companies first started to diminish engineers were able to reestablish a position of prominence - at least, in American firms - by applying their knowledge of machines to the management of people. The result of

this was the development of Scientific Management techniques for the purpose of increasing output and facilitating employers extraction of surplus value (Armstrong, 1984a: 3, 8).

Since that time economic crises have necessitated further reorganisation of industry and the accountants have used their knowledge of financial criteria to gain a position of prominence. Armstrong argues that the decade of the 1920s was particularly significant to the accountant's rising trajectory in both the USA and Britain. American companies' response to the recession of the time was to introduce the M-form type of organisation to simplify administration at each of the new divisions. Accounting techniques were important in conducting relationships between the divisions as, to quote Chandler, they provided the:

"essential tools by which the visible hand of management was able to replace the invisible hand of market forces in coordinating and monitoring economic forces" (Chandler, 1978: 448).

Up until the inception of the M-form of organisation accounting and financial personnel had simply been one group of staff who provided an advisory function for line management. Accountants' possession of a repertoire of dispassionate financial techniques which could be used for co-ordination of a firm's activity then helped the financial personnel to move to a central position at the administrative head of the divisionalised American firm. Armstrong (1984a: 14 - 15) says:

"To put the matter very crudely, accountants displaced engineers and other operational managers from key positions within the global function of capital because decisions of allocation between dissimilar operations could only be made on a common abstract - and therefore financial - basis."

Armstrong reports that the position of accountants in Britain follows a similar trajectory. In the middle of the nineteenth century legislation was passed that aimed to protect the interest of investors as first the railways and then a number of industrial ventures drew capital from a wide range of sources. The legislation had provisions for the conduct of audits. The performance of this "allocation of surplus value" function gave accountants a foothold in the enterprise (Armstrong, 1987a: 419 - 420). From this position they were subsequently able to spread their sphere of influence into other areas. We have already seen from Loft's (1986; 1988) work that legislation in the First World War created work which accountants used to negotiate an extended role for themselves. Armstrong (1987a: 424 - 5) reports that, subsequent to the economic recession of the 1920s, financial personnel have extended their influence yet further by instigating their own supervision of new capital sanctioning procedures.

For Armstrong, the changing nature of the enterprise and wider society is only part of the explanation: It does not explain fully why the accountants have been able to wrest control of particular techniques from engineers. In attempting to answer this question, Armstrong (1984a: 5, 9) utilises Jamous and Peloilles' (1970) concepts of technicality and indetermination. Technicality refers to the codifiable elements of a profession's knowledge base. Indetermination refers to the non-codifiable elements such as charisma and ascriptive qualities. The more of the qualities of technicality that are embodied in a profession's knowledge base and the less of the qualities of indetermination, the greater is the probability that other occupational groups will expropriate the

important resources of a profession. Industrial engineers fell from their position of prominence because:

"the techniques of scientific management proved too lucid and could too easily be detached from the ambitions of the engineers" (Armstrong, 1985: 132)

As a consequence, the practices of job timing, planning and organising were either appropriated or replaced by analogous techniques belonging to other fractions of management, in particular accountants. Armstrong argues that the engineer's situation has not been helped by the physical nature of their product. Other groups such as solicitors and accountants produce a service and the particularistic and intangible nature of this allows them to monopolise evaluation of the effectiveness of their work. By contrast, engineers produce a concrete and durable product which may be evaluated, subsequently, by others (Armstrong, 1984b: 108). The relative accessibility of measures of quality of what is produced determines the extent to which others may challenge the authority of practitioners.

Accountants have also been helped in their aspirations by the nature of capital markets in Britain and the USA. Whilst there was some collaboration between banks and industry at the inception of industrialization in Britain, a separation of finance and industry soon developed. The localised nature of the banks and their limited funds meant that any long term investment tended to create crises of liquidity for banks and a number of banking failures (Armstrong, 1987a: 420 - 421). The result of this separation was legal compulsion to perform audits as a pre-condition for generating new funds from stock markets. This has increased the importance of the

accountant's role.

Even with Armstrong's modifications "Labour Process Theory" is inadequate. Conflict does not only revolve around the Capital-Labour axis and/ or rivalry between different fractions of management on who offers the best technique for providing a solution to a problem that is confronting Capital. It is possible to envisage different scenarios of problems in the workplace and potential solutions which cut across class lines and draw support from different strata. For example, implementation of equal opportunities policy, "green" alternatives and, in the context of this thesis, choices of systems in pursuit of one set of manufacturing objectives rather than others when all offer comparable levels of profitability.

What is more, Armstrong's arguments imply that accountants and accounting criteria enjoy a position of authority over engineers in any decision-making process. Yet there are a number of reasons why this should be questioned. First, as the work of Jaikumar and Johnson and Kaplan illustrate, it appears possible for new systems of manufacture to be introduced, even though accounting criteria are incompatible with the logic in such systems. This suggests that Armstrong may be confusing simple location of different groups of personnel in a company's structure with their ability to make an effective intervention in decisions on capital's behalf. Second, the arguments that prompted this research suggest that the techniques employed by accountants are generating false information, which is resulting in work systems being employed ineffectively. Accountants could, thus, be creating crises for capitalist firms rather than resolving them. Yet it is the ability

to perform the latter which is reported to provide the bases of accountants' superior position in the enterprise. Third, if Armstrong's work is read in conjunction with his (Armstrong, 1988) writings on the organisation of work, the practical application of accounting would be to only favour the introduction of systems which deskilled workers. The validity of this view has already been challenged in Chapter One.

Discussion.

The aim of this section was to examine whether any theory of accounting could provide insights into the consequences of the theorized current conflict between accounting practices and flexible manufacturing systems. To this end four theories of accounting have been examined. All of the theories considered are able to explain the pattern detailed in the preceding section that accountants enjoyed a position of greater stature in the upper echelons of a company and that their analysis may override engineering decisions made within the firm. However, three issues that have relevance to this thesis have been considered and the theories differ from one another on at least one of the following: the validity or extent of "truth" that is perceived to exist in the accounting analysis; the scope for any divergence in analyses and proposals of accountants and other groups such as engineers; and the bases of accountants' power which allows their analysis to take precedence over others in the enterprise.

In the conventional view of accounting nothing other than "truth" is generated by the accounting analysis and this provides the source of authority of accountants. No divergence takes place

between the analyses of accountants and engineers, as both subscribe to the same rationality. By inference, current conflicts between accounting and engineering systems are transient and will be rectified. The "Changing Cost of Accounting Information" theorists view the important source of accountant's power as the universality of accounting language which allows dialogue and alliances with powerful external forces. Accounting techniques are not sufficiently complex to produce valid interpretations of all events, especially the production changes being presented by engineers, and this is leading to a threat to different companies' financial viability. Either accounting systems are changed or American companies will suffer further demise. In the "Genealogical Approach" it is the ability to exploit a range of general and historically specific situations which provides the bases of accountants' power and enables them to generate information which strengthens their position further. As accounting "replicates" the production process no divergence between accounting and engineering would appear to take place. If it does, as knowledge is power, accounting systems' misrepresentations of financial reality will serve to undermine the standing of accountants. According to "Labour Process" theory, accountants derive their power from allegiances with Capital. They may diverge from engineering proposals in defining routes to profitability but if they were failing to articulate profitable options their position of dominance would be challenged.

None of the theories appear to be able to provide total resolution of the problems confronting this thesis. They all generalise the accounting analysis as either applicable or

inapplicable to current times and they all tend to overstate the extent of each accountant's power in applying the analysis. The different theories can be divided into two. On the one side there are the optimists. These include the "Traditional" theorists, the "Genealogical" school and writers from the "Labour Process" tradition. These all view accounting as meeting their designated objectives for the owners of companies. If they did not, in time, there would be a challenge to their position. On the other side there are the pessimists. These include the American "Accounting-Engineering Discord" school and other critics of current accounting practices (see Chapter Four below) who provide what T.C. Jones (1990b) has described as a "Failure Thesis". That is, accountants are providing the wrong information which could eventually lead to the demise of the companies. There are two possible reasons for such a pronounced difference of opinion. The pessimists overstate the extent to which the structure of accounting logic is incompatible with FMS. Alternatively, the optimists overstate the extent to which the accountant is able to act independently to resolve the problems that arise when there are changes in the external environment such as when a new manufacturing system is introduced.

It is the contention of this author that both are overstatements that arise because the optimists and the pessimists tend to view the everyday application of accounting channelling in a single direction from the accountants themselves. That is to say, accounting techniques are seen to be the possession of, and administered by, accountants. Others are perceived as simply the recipients of those administrations. The consequences of this is

that the theories of accounting tend to provide "formalist" explanations that equate the power of accountants with their official location in a company's hierarchy and the presence or otherwise of formal accounting techniques. This misrepresents the effective influence of accountants. As the preceding section outlined, accountants' application of accounting techniques takes place after engineers["] have made their contribution to the financial decision-making process. This does not allow accountants to determine exactly what their own contribution to that process will be. They may, either correctly or incorrectly, rule that engineers' submissions are invalid. But this raises the issue of what accountants will put in place of those submissions. It will be explained in the next section that accountants have limited ability to act in this way independently of engineers. Alternatively, the accountants may accept engineers' proposals. This dependency of accountants on engineers for information serves to limit the potential divergences of accounting standards from engineering systems. Thus, accounting should not be seen simply as the possession of a single group within the enterprise. Instead, they are practices that are constructed by accountants in conjunction with others. In order to understand this more limited role of accountants in British firms it is necessary to investigate how that role developed. It is to this issue that we now turn.

2.4 Engineers and Accountants Knowledge of the Shopfloor.

The main objective of this research is to examine whether the application of accounting techniques in the evaluation and monitoring of manufacturing systems results in utilisations of FMS that are to the detriment of the company that installs them. So far in this Chapter it has been reported that accountants hold a formally superordinate position to engineers and this gives them the opportunity to apply accounting standards to engineering systems. It has also been argued that accountants are not in a position to act without reference to the content of engineers' interventions. To do so would require extensive knowledge of shopfloor processes. For example, when the pre-investment justification is carried out accountants would need to have independent access to the relative values of existing and prospective processes. When the post-installation controls were implemented accountants would have to be able to (i) stipulate independently the standards of performance that a system should obtain, (ii) monitor whether they are being achieved and (iii) subsequently impose the mode of working that will ensure realisation of the stipulated standards of performance if these were not being achieved.

A discussion of the development of cost control in Britain will demonstrate that accountants have never gained access to the full details of shopfloor processes. First, this section will provide a description of the extensive form of cost control that the Scientific Managers in the USA sought to develop. This will serve to highlight the limited nature of the knowledge of shopfloor processes of accountants in British firms.

(i) The Development of Cost Control in America.

In the last quarter of the nineteenth century, ie, the 20 year period prior to the development of Scientific Management, the American economy experienced rapid industrialisation. High levels of production of increasingly standardized goods were being obtained due to the growing mechanisation, product specialisation and fragmentation in the use of labour (Littler, 1982a). A growth in homogenous markets fuelled this process: the rapidly expanding population included many immigrants "whose ancestral diversity of tastes had been erased by transportation to the New World" (Piore and Sabel, 1984: 41). As income distribution was less skewed than in other industrialised nations (Chandler, 1976: 47) and wages were higher than in Europe due to American industries' increasing efficiency (Littler, 1982a), this growing population had the capacity to purchase the goods manufactured.

Industries in the USA were, however, confronted by one major problem: they suffered from a shortage of skilled labour (Piore and Sabel, 1984: 40), which was accentuated by, and manifest in, the skilled-labour turnover of between 100% - 300% per annum (Sayer, 1986: 44). The immigrant workers lacked both industrial experience and the time discipline that accompanies it (Hill, 1981: 24) and did not provide employers with a ready made solution to the skilled labour shortage. These conditions appear to have provided fertile ground for the development of a system that could employ the mass of unskilled "green" immigrant workers, induct them into the time discipline of industrial work, pay them relatively high wages and still improve companies' profitability by increasing output of standardised goods.

It was in this context that Scientific Management with its prescriptions for the single best method found a space. The most famous proponent of this system of work reorganisation was Frederick Taylor. Whilst the extent to which Taylorism was diffused in the USA is open to interpretation (Nadworny, 1955; Nelson, 1974; cf. Drucker, 1954, Littler 1982a). Even the studies which suggest that Taylor had only limited influence report comprehensive installations of his system at a number of major companies. It is, therefore, of value to use Taylor's (1903; 1911) works as the focus for this part of the discussion.

Taylor sought to develop a "scientific" method for determining a single best way of performing each job of work. He believed that the resulting increases in labour's efficiency and productivity would produce rewards for everyone and promote harmonious relationships between workers and employers. Taylor's proposed methodology for establishing the best work methods was for the works engineer to observe a number of people conducting the same task. The engineer would conceptualise each of the constituent elements of the operators' different techniques and time them for their efficiency. He would then reconstitute the process by assembling the most efficient movements used by the operatives into a single best method. Thus, Taylor standardised the way of performing each task.

Scientific Management's next concern was to define actual output levels by determining "what really constituted a full day's work that a man could properly do, year in and year out, and still thrive under" (Taylor, 1911; 55). This involved identifying the important aspects of a task which led to a person tiring, and

pacing the conduct of these activities and the timing of breaks so that the desired level of work could be attained on all days. This implied a standard level of output for each worker and a standard time for performing each task.

To ensure that each operator enjoyed an equal opportunity of realising the stipulated output the engineer would define the layout of the materials and the tools which were to be used for the purpose in hand. Taylor stated that:

"the workman should be given such standardized conditions and appliances as will enable him to accomplish his task with certainty." (Taylor, 1903, pp 63 - 4. My emphasis.)

The works engineer also had the responsibility for matching suitable workpeople to each job according to the demands of the work and the attributes of the individual. The employees who were selected to perform shopfloor tasks were inducted into the mode of working by a member of the supervisory staff who understood the logic of the new methods. Supervisors were expected to demonstrate the techniques to the worker and then oversee the operatives to make certain that each worker observed the correct method of working and rested at the appropriate times to ensure optimum performance. Taylor's theorized standard method of working was thus enacted in practice.

Taylor also proposed the setting up of a planning department. This was to have many functions (see Taylor, 1903: 112 - 120) but its overall objective was to make sure that no process on the shopfloor went ahead without its consequences being evaluated in advance: diagrams and maps in the office replicated the layout of the shopfloor (Taylor, 1911: 39). These were to be used to identify

in advance routes of parts, methods of production including the machine tools to be used, the speeds of machine tools and the volume of output from each worker. Shopfloor staff received written instructions about their tasks from the planning office. An optimum level of efficiency from the whole factory could then be realised. Taylor's work, thus, provided clear stipulations for how the Scientific Managers could define the single acceptable contingency for the functioning of the whole production process. This entailed standardisation of all the constituent operations in the work process to ensure optimal performance regardless of which "scientifically" selected workers were performing the tasks. The only dimension of their own performance that operators had to concern themselves with was the extent of their own exertion in achieving the number or volume of output requested.

The standard cost method of cost control was both predicated on, and a natural extension of, the above standardisation in the work process. Epstein says:

"Standard cost accounting techniques can be viewed as the ultimate in refinement and sophistication of the scientific management principle." (Epstein, 1978: 95.)

Epstein (1978) demonstrates that the development of a system of standard cost was by Scientific Managers at those companies where systematic work re-organisation had already taken place. As a result the system of financial control utilised and extended the Scientific Manager's knowledge about efficiency of different functions. Key stages in the development of standard costing came from Emerson and Harrington. Emerson used the theorized notions of efficiency in the standardised method described above to determine

a standard cost for producing goods and performing particular tasks. This could then be used to provide a budgetted sum against which actual performance could be compared (Emerson, 1908. Reported in Epstein, 1978: 100 - 104.) Harrington extended this process. As described above, the Scientific Managers sought to control every contingency in the overall work process so that labour had only to provide the effort necessary to drive that process. Harrington identified the different contingencies that was assumed in the standardised method - such as speed of machines or optimal organisation of machine time - and other factors that affected overall costs, and measured the actual performance of these against standard. This allowed isolation of the different causes of the variance in a factory or department's budget. (Harrington, 1919. Reported in Epstein, 1978; 118 - 120.) Thus, the Scientific Managers could identify immediately why costs rose and who it was that was responsible for this. For example, it was possible to identify whether it was due to employees' lack of efforts, the fault of the planning department in not routing work efficiently, or a consequence of some outside source such as a rise in the cost of raw materials.

In short, Scientific Managers sought a total knowledge of shopfloor processes which allowed them to construct a system of cost control from the bottom up. They were able to stipulate exactly what the physical work process should be. They controlled the machinery that monitored the work processes and its output and, as a consequence, they could reintroduce a standard method of working if operatives veered from the mode of operation in which they had been instructed. The Scientific Managers were also

responsible for translating production performance into financial terms. They were, thus, able to view directly the economic efficiency of each physical process. What is more, the Scientific Managers were mechanical engineers who had applied their knowledge of machinery to work layout and people (Armstrong, 1984a: 3, 8). Therefore, they were able to act independently in their assessments of whether new plant would improve the efficiency of a given process. The Scientific Managers were, theoretically, in possession of all relevant manufacturing, engineering and financial knowledge pertaining to a company's shopfloor operations.

There is no intention here to infer that such a totally comprehensive system of Scientific Management and cost control ever worked as the Industrial Engineers intended. It is highly unlikely that it did. There were too many factors that militated against its operation: there were gaps in the Scientific Manager's thinking. For example, Taylor never provided a systematic way of defining what was "a full day's work that a man could properly do, year in and year out, and still thrive under". (See, Littler, 1980: 1982a.) Employers did not always give the Scientific Managers sustained support for full implementation of their systems. (See, Rose, 1975, for an account of some of Taylor's experiences.) Perhaps, most importantly, the possession of knowledge of work processes by managers does not mean that the workers themselves have been dispossessed of their understanding of the same process (Kelly, 1982). US studies of more recent times have shown that workers are able to use their knowledge to manipulate representations of what actually happens in the work process and present a false picture to managerial staff. Thus, whilst work may appear to the latter as if

it conforms to their designations, at times output targets are being exceeded to compensate for shortfalls at other points (Roy, 1955; Burawoy, 1978). Therefore, the above description of Scientific Management and the accompanying standard cost method that was developed in the USA in the early part of this century should be seen simply as an "ideal type" (2). Nevertheless, it was an "ideal type" that afforded to those responsible for the financial evaluation of production methods full access to the intricacies of the manufacturing process. This was not the case in Britain.

(ii) The Development of Cost Control in Britain.

Britain's conversion to an industrial capitalist economy took place earlier and over a longer period of time than had been the case in the USA. This was to have implications for the distribution of knowledge of shopfloor processes. For example, skilled workers (Littler, 1982b, 130 - 1) were not an uncommon feature of the small independent companies that prevailed (3). As businesses were small-scale, owners often managed their own firms. The managerial staff that were employed had an engineering background (Armstrong, 1984b: 106). The owners' spirit of independence made them reluctant to borrow from outside sources to fund any expansion (Payne, 1967: 526). This, coupled with the widespread presence of sub-contracting systems which spread capital risks (Littler, 1982a: 67) and the high profit margins which the early entrepreneurs enjoyed (Armstrong, 1984a: 13), contributed to the initial phase of industrial development taking place without any form of systematic cost control. With a few notable exceptions (4) accounting

throughout the nineteenth century was directed at auditing, rather than managerial control purposes (Puxty, 1990: 351). Thus, whilst shopfloor workers and engineers were in possession of knowledge of manufacturing processes, accountants were not.

Around the time when American firms were starting to develop new methods of working and, subsequently, cost control the internal sub-contracting system started to break down in Britain (Littler, 1982a). However, a number of factors were to militate against the British firms adoption of the standardized methods of production that had provided the American Scientific Managers with the opportunity to accumulate a comprehensive knowledge of all dimensions of a company's manufacturing operations. First, companies' experimentation with new payment systems after the breakdown of the sub-contracting system led to the intensification of industrial conflict in the 1890's (Littler, 1982a). This discouraged employers from introducing new work methods such as Taylorism for fear of further antagonising labour (Lewchuk, 1983). Second, the pattern of ownership described above did not encourage investment in new techniques. Britain's early industrialisation left a legacy of methods which, although not necessarily efficient, did offer a no risk return (Hill, 1981: 38). Any need that companies may have felt to experiment with new methods was alleviated further by their access to protected Empire markets (Zeitlin, 1983).

The pattern of demand for British goods did not encourage the introduction of standardized methods. Markets were more heterogeneous than those serviced by American producers. Home consumers demonstrated a taste for craftsmanship and individual

character whilst exports went to consumers in different commonwealth countries where conditions and tastes varied considerably (Payne, 1967).

Heterogeneous markets are best catered for by the use of general purpose machinery. These require skilled labour (More, 1982: 116 - 117). Thus, just prior to the First World War skilled workers constituted half of the workforce in many large industries including engineering (More, 1982: 113). By contrast, the development of any form of financial monitoring controls at this stage can, at best, be described as sketchy. (See, for example, Loft, 1988: 112.)

Yet, whilst engineering employers either could not or would not introduce new methods of production that might have given them access to detailed information of shopfloor operations they were subjected to pressure from another source to introduce accounting controls.

Loft (1986; 1988) has described the First World War and its immediate aftermath as the period when cost accounting "came into the light". She reports the increased significance of costing at this point as an outcome of the political and economic pressures peculiar to a wartime economy. Thus, to state briefly Loft's argument: Following the build-up of political pressure the Government attempted to prevent profiteering when the market could not operate freely to determine prices. The mechanisms which the Government selected to define a fair price were contingent on the development and application of cost accounting techniques and this led to the more widespread use of cost control.

Loft explains that in the course of the First World War the

State's direct involvement in the internal affairs of the country reached an unprecedented scale: The Government took responsibility for purchase of goods and materials both for military purposes and the sustenance of their population. However, the prevailing principle of competitive tendering for Government contracts led the competing companies' to demand materials in advance of their winning of contracts." The outcome was that the cost of those raw materials rose and so did the eventual cost of production to the Government.

Pressure from both civilian and military circles built up on the Government to regulate product costs and prices following the "Shell Scandal" early in 1915. In this episode a military offensive had failed because Government-imposed financial constraints had led to the imposition of limits on the number of shells which could be used daily. Pressure for changes to the methods of pricing also came from the labour movement who were concerned that war time dilution of skilled labour should not be permitted to increase the profits of employers. The setting up of the Ministry of Munitions and the passing of the Munitions of War Act ensued.

Loft (1988: 146) reports that the latter made provisions for the creation of a category of "controlled establishments" of plants whose production was "essential to the manufacture of munitions". Wages and conditions, staffing levels, choice of operatives and the organisation of work in these plants were open to sanction by the Ministry. Their profits were also limited to a standard based on their pre-war level by a "munitions levy". Loft reports that the Government subsequently introduced mechanisms for establishing a fair market price by inserting a new clause into the Defence of the

Realm Act in 1916. These standards were:

"In determining such price regard need not be had to the market price, but shall be had to the cost of production of the output so requisitioned and to the rate of profit usually earned in respect to the output of such factory or workshop before the war." (Quoted in Loft, 1988: 149.)

The different mechanisms which the Munitions of War established for determining this were:

"(i) Technical costing. "the estimate of costs by engineering experts resulting from an analysis of the process of manufacture into its elements, and the calculation of what the costs of each of these ought to be in the light of all known conditions."

(ii) Accountancy costing: "the ascertainment of any given contractor's actual costs of production by examination of his books."

(iii) Using the cost returns from National Factories where similar articles were being produced.

(Ministry of Munitions, unpublished. Vol 3. part 2. ch 1. pp. 10 - 11 quoted in Loft, 1986, 144 - 5: 1988, 150).

The first method is the one that resembles most closely the introduction of the cost control methods that were part of systematic management in the USA. However, according to Loft (1986: 1988) it was the third method which was the most popular. Loft reports that quite sophisticated costing methods were set up in National Shell Factories (Loft (1988: 150 - 1). This involved finding out the process costs of shell manufacture by discovering the cost of labour, materials and establishment costs for the given output at each process that the shell passed through. Information on variances due to either bad work or faulty materials were also ascertained. From this, the average cost of each process was computed and the aggregation of average costs of the different processes gave the average total cost of the shell. The information

obtained then provided a basis for comparisons between factories and within the same factory across time.

Nonetheless, from Loft's work it would appear that only aggregate costs, albeit determined by itemising costs of production at National Factories, were used when the Government purchased parts from other engineering companies. In other words a maximum budget for producing a given volume of parts was set by the Government. This gave accountants the role of introducing and administering costing systems in manufacturing enterprises (Loft, 1986: 1988). However, there are a number of reasons for believing that the content of the activities of shopfloor workers and engineers remained shielded from the accountants' gaze and that the coverage exercised by costing systems was never as extensive as in the USA.

Firstly, the same Munitions Act that had prompted companies to introduce cost monitoring techniques also protected the rights of shopfloor workers to exercise a degree of influence over their immediate work situation. This gave rise to the Shop Stewards' Movement. Lewchuk has said of the relevant provisions of the Act:

"The Munitions Act differed from the EEF proposals. Only customs which directly reduced output were challenged. Of equal importance management was not given the sole authority to decide which practice reduced output. The Government became the final arbitrator. Unlike direct control which eliminates the need for management to confer with labour, the Munitions Act had actually increased the need. Increasingly these consultations took place at the point of production." (Lewchuk, 1983: 89. Emphasis added.)

Secondly, Loft (1988: 149) reports that the aim of the Munitions Act was to hold profits to a pre-war level. Yet, profits

were already exceedingly high in the munitions industry. Increased military expenditure and rearmament in the decade before the start of the war ensured the financial well-being of armaments companies. Zeitlin (1983) reports that Sir Andrew Noble of Armstrong-Whitworth claimed that his company could make more money from building a single river boat than from manufacturing 6,000 cars. Thus, the introduction of the Act was unlikely to have placed any great squeeze on profitability that might have otherwise prompted companies to reduce costs by potentially disruptive reorganisation of production.

Thirdly, Littler (1980; 1982a; 1982b; 1985) has dated the movement towards systematic management in Britain as taking place after the First World War. Finally, engineers and accountants already existed as different groups operating in different spheres within the company and with markedly different frameworks of analysis and knowledge. This was likely to prevent the accountants from intruding into the realms of engineering even when manufacturing performance was not as anticipated. The divergence between engineers and accountants at this early period is best illustrated by Loft's (1988) report of an instance in the professionalisation project which the ICWA embarked on after their inception in 1919.

At a number of firms the ICWA won the right to organise the personnel who were supervising costing techniques. The tactics which the ICWA employed in their quest for recognition and authority included selection and exclusion of membership, definition of their relationship to other bodies and identification and refinement of their own knowledge base. Thus, there was some

discussion on their relationship to engineers and that group's professional expertise. "Workshop knowledge" was included in the ICWA syllabi and amongst exam topics. However, from Loft's work this appears to have been perceived by the majority of the members of the ICWA as a subsidiary and relatively unimportant element of their expertise: a debate on the relationship between engineering and cost accounting took place in the pages of The Cost Accountant. A deluge of protest letters brought a revision to an editorial that had implied that a practical level of training in engineering was essential to cost accountancy. Thus:

"The author had to explain that he had not meant to imply that the "most suitable approach to Costing was to be gained through a thorough apprenticeship in engineering ... ". He said that he had been trying to make the point that "technical knowledge" was important for grappling with the "higher branches" of the work such as "the relationship of design to cost, or the presentation of a statement showing the relative cost efficiency of rival process methods ..." (The Cost Accountant, November 1922, p. 165)." (Loft, 1988: 230 - 231.)

All of the above factors highlight how knowledge of the engineering and manufacturing dimensions of production processes remained the prerogative of shopfloor workers and engineers. Unlike Scientific Managers in America, the accountants remained dependent on others to furnish them with details of shopfloor practices.

After the war cost accounting was introduced as part of a movement towards systematic management in the newer industries such as cycles and sewing machines. However, it does not appear that this gave accountants the same degree of knowledge of shopfloor production activities as had been enjoyed by the Scientific Managers in the USA. The most common method of systematic

management introduced into Britain was that devised by Bedaux. Littler (1980: 376) reports that there were 225 installations of this system into firms in Britain by 1937.

The Bedaux system was not a comprehensive system of work organisation. Instead it revolved around a definition of the fatigue which workers were likely to experience in the course of their work as a consequence of performing different motions such as lifting, pushing, pulling or pressing.

The method for installing the Bedaux system (see Littler, 1980; 394 - 8) was for departments to be rationalized individually. The first department would be identified and the conditions external to the worker in that department, namely regularity of material supply, routing of work, machine speeds and feeds, etc., would be standardized (Littler, 1980; 396). The rationale for this was that the operatives could then perform their work at their most efficient pace. The tasks which the worker was performing were analysed into their constituent elements and the operator was timed for his or her efficiency. The standard of efficiency which the operator was supposed to work at was defined as 60B. Littler (1980; 397) reports that if the observer believed that the operator was working at an unnecessarily slow pace the observer would rate the volume of work produced in that period at a level lower than the 60B.

Once the information on the types, timing and efficiency of movement had been collected they were then despatched to the central planning office. Here, the efficiency engineer defined the workload for each operative by adding estimated time allowances for fatigue and unavoidable delays to the work study staff's

observations of the time taken to perform different tasks. Bonus systems of payment were then constructed around the definitions of workload. Operators, supervisors and departments were measured against the designated B-factor and sanctions could be invoked if either the operator's or the supervisor's performance was below par. In this way a system of cost control was instituted.

There are a number of important variations between the Scientific Management of Taylor and Bedaux's system. As a consequence, the users of the latter did not share the same capacity of their American counterparts to influence the conduct of shopfloor activities. Firstly, Bedaux had little to say about work design. The work study engineers simply timed the workers operations and then determined the amount of rest required. The content, if not the breadth, of the work operation was left to either the operator or existing supervisory and management personnel to decide. Taylor, on the other hand, had specified how tasks were to be performed. He was concerned with eliminating "awkward, inefficient or ill-directed movements" as well as getting workers to increase their efforts. Secondly, Taylor's definitions of the work environment was meant to enable the worker to carry out the operations as scientifically determined by the works engineer. In Bedaux it was used to drive the velocity of throughput. The Taylorites tried to dissociate themselves with Bedaux as they were afraid of the stigma of "sweating" or "speed-up" due to the latter's failure to provide details of how the employee should change their methods to increase their output (Littler, 1980). Thirdly, work volume in Taylor's system was determined by reference to the number of items which the worker could be expected to make

using the method designated by the works engineer. The volume in Bedaux was determined by calculating the rest time which the worker needed. A system of bonus payments was then linked to levels of output to ensure that the pace of work was achieved. By contrast, Taylor perceived the type of payment system that was used as a subsidiary element of his scheme. The main purpose was to reward workers for following the Industrial Engineer's exact instructions. Bonus systems such as those used by Bedaux are most necessary when managers do not exercise direct control over shopfloor activities. Hopper et al. state:

"the logic of productivity schemes and piece rates is intended to provide management with control of output without their having to bother with detailed work practices, direct supervision or elaborate formal controls" (1986: 5; emphasis added).

Finally, in Taylor's system the exact operation of work tasks was demonstrated by supervisory staff and workers were systematically inducted into the correct mode of working. The only way that the Bedaux system encroached on work operations was by the setting of the B factor according to how efficiently the time study observer believed the operator to have worked.

Clearly, there was an element of control over shopfloor processes in Bedaux's system. It enabled those responsible for cost monitoring to define a volume of output that workers could be expected to produce and to identify the areas where the numbers of output fell short of what was anticipated. However, the definition of standard output which systematic managers provided largely accepts the traditional method of performing a task as defined by the workers or by existing managers. Unlike Scientific Management

of the Taylorian variety the Bedaux system did not seek to define exactly how workers should realise their output but simply assumed that the most effective method was the one being employed. Indeed, one of the major attractions of Bedaux to employers was that it did not involve "restrictions on the authority of traditional management" (Layton, 1974: 383).

This is not to deny that the personnel who were responsible for monitoring performance of departments could invoke sanctions against shopfloor staff who failed to meet their output targets. Littler (1980: 383 - 8) provides details of Bedaux's own "Factory Posting Sheet" which was a public statement of performance and, thus, an explicit warning to those who were performing below the par of 60B. However, the person responsible for monitoring did not have the knowledge that would have allowed them to institute a particular mode of working if the desired level of output was not obtained. They had predicated their definitions of standards on the operations that existed. By contrast, the American Scientific Managers had constructed their own definition of what the standardized operations should be. Thus, even at those factories in Britain where some notion of standardization in work operations had been introduced, accounting staff failed to acquire intricate knowledge of manufacturing and engineering dimensions of shopfloor operations.

There have been other factors since Bedaux that have led to companies introducing accounting controls. The merger of different companies into corporate groups from the 1920s onwards (Hannah, 1976) has created the need for some type of financial co-ordination (Armstrong, 1987a). However, the form of corporate ownership that

existed prior to the Second World War was loose federation of firms amalgamated through a holding company with each continuing to function as it had under its previous form of ownership (Payne, 1967). As the prevailing financial control method adopted by these groups was audits of their constituent firms (Armstrong, 1987a: 425) it does not seem unreasonable to suggest that accountants never extended their view of shopfloor activities.

Later, in the Second World War the Government again took action to protect against profiteering. However, the method which they used was inspection of a company's books and rationing of materials (Armstrong, 1987a: 426). It appears unlikely that this would have brought any great pressure on companies to extend shopfloor accounting controls on the shopfloor.

In the post-war period there have been a number of pressures on British companies to extend "American" techniques. Tomlinson (1987) reports a number of Government education initiatives aimed at increasing productivity through the adoption of American methods including cost control. The multi-divisional form of organisation has often been adopted following recommendations by American firms of consultants (Armstrong, 1987a: 430) and multi-divisional organisation grew in prominence in the 1960s (Steer and Cable, 1978) and was to be found more frequently than the holding company by the 1970s (Chandler, 1976). The overall effect of this has been a change in the method of cost control. In the 1960s historical costing predominated in British companies (Parker, 1969: 11 - 12) but by 1990 standard cost techniques were used in the majority of firms (Iyall, Okah and Puxty, 1990: 44 - 5). Despite this switch in the techniques employed, it is unlikely that such a change has been

accompanied by re-organisation of the shopfloor: any transfer of American techniques post-dates America's own adoption of the multi-divisional form which, according to Johnson and Kaplan (1987), was when American companies switched to using standards for valuing inventory rather than as a means of controlling shop-floor activities.

The work of a number of authors also highlights the fact that accountants' ability to direct work activities remains limited. Engineers maintain a large degree of autonomy and control in different projects (Whalley, 1986). Shopfloor management continue to hold considerable responsibilities (Hill, 1981: 31) and many skilled workers in engineering have continued to exercise the right of deciding how a job is to be carried out, the sequence of operations and the speed of production (ibid.)

Part of the protection against the accountants' incursion into the activities of the shopfloor in Britain is the predominance of small batch production (5) and the complexity which is involved in this form of work. Turner (1970) quotes Loveridge and Sawyer (1968), who point out that anyone searching for the optimum way of scheduling 9 jobs with 3 operators on 3 machines is faced with 47,784,735,839,827,000 possible routings. Turner found that because of the complexity in production, cost prevented firms from planning workflow in advance. Instead, work was allocated to available machines to meet shortfalls in available stock when orders were pending. If companies are unable to allocate work in advance they will not be able to stipulate the exact method of working and accountants are unlikely to be able to enforce a particular use of a given machine. In short, accountants' knowledge of shopfloor

activities is limited and engineers, shopfloor management and workers all maintain a degree of autonomy in their respective areas of work.

None of this is intended to deny that accountants do enumerate different activities that go on on the shopfloor or that they define as problematic levels of output which fall below a given level. Nor is it being argued here that there are not biases in the dimensions of performance which accountants seek to quantify. There clearly are. Present day accounting techniques are focused disproportionately on labour savings rather than other criteria. Both New (1976: 15 - 16) and New and Myers (1986: 7) report that currently the most important cost to companies is bought out materials. Yet companies still dedicate the resources used to control performance to the monitoring of direct labour input. New and Myers claim:

"For the average plant in our sample, a 10% reduction in the materials purchase content would reduce total factory cost by 5.1%, whereas a 10% reduction in the direct labour requirement would reduce total factory cost by only 1.8%. That is to say, purchasing effectiveness has a "leverage factor" almost three times the "leverage factor" of direct labour. Moreover, a specified percentage reduction in purchase costs is probably far easier to achieve than the same percentage reduction in direct labour content - with all its ramifications for manning levels, etc." (1986: 7).

What is being asserted here is that accountants have failed to establish the means for acquiring knowledge of the manufacturing and engineering intricacies of production processes in British firms. This leads to accountants being dependent on other personnel such as shopfloor management and engineers to identify the most

efficient processes and the numbers of output that may be obtained. It is only after engineers and others have done this that accountants can attach costs to different processes. In effect, the construction of accounting standards takes place in conjunction with other groups of personnel in the firm. They are not applied unilaterally. This contrasts with the American Scientific Managers who identified the most efficient processes and defined both the acceptable standards of output and the costs that would be incurred in this.

In summary, this section has contrasted the different histories of cost control in USA and Britain. It has illustrated that cost control in the USA developed as a corollary of work reorganisation by the same Scientific Managers that had instigated the initial re-arrangement of the work process. This gave rise to a holistic form of cost monitoring that allowed the Scientific Managers to assess the engineering, manufacturing and financial merits of different operations. By contrast, Britain's early industrialisation resulted in forms of cost monitoring being introduced at different times to work reorganisation. Different personnel are, thus, responsible for engineering, manufacturing and financial dimensions of performance. Accountants who supervise the latter are dependent on others to provide them with details of engineering and manufacturing dimensions of performance.

2.5 Conclusion.

The main concern of this thesis is the extent to which deployment of accounting techniques may result in the misuse of FMS systems. This Chapter has aimed to examine the ability of

accountants to employ an analysis which results in such an outcome. It has been explained that the accountants hold a position higher in a company's formal structures and make their interventions later in the decision making process than do engineers. A number of theories of accounting have been examined as a means of understanding the source of this apparent power of accountants and the extent of the validity of the accountants' analysis. It has been reported that the different theories suggest a number of different factors that contribute to accountants superordinate position ranging from expertise in performing accounting tasks to the ability to converse with outside forces, develop allegiances with owners and to pursue successfully professionalisation projects. This thesis does not dispute the relevance of these factors.

The theories of accounting differ from one another in the extent of "truth" that they perceive to exist in the accountants' analysis. One set of theorists views accounting techniques as totally inappropriate for evaluating and monitoring FMS, whilst others demonstrate a faith that accountants have the ability to remedy, independently, any weakness that may arise.

It has been argued here that all of the theorists overstate the extent of the power of accountants. The limits to accountants' power has been explained through a comparison of the development of financial controls in the USA and Britain. In the former, Scientific Managers sought a holistic comprehension of the production process, whereas, in the latter, accountants only have financial understanding of manufacturing activities. This limits the power that accountants may exercise when technical change takes

place at firms in Britain. Therefore, a detailed examination of the role of engineers in the process of technical change to FMS and the construction of accounting controls is necessary. This will be provided in Chapter Five below when consideration is given to how the relationship of accountants' formal superordination over engineers, modified by their dependence on the latter for information, is manifest in the capital sanctioning route. First, the nature of FMS and the manufacturing benefits that it brings will be examined.

Footnotes.

(1) The classical explanation of the development of depersonalised formal organisations that aim to realising a given set of objectives has been provided by Max Weber. (See, Weber, 1946). However, the description of rule bound procedures in Weber's "ideal type" of formal organisation, bureaucracies, does not allow the organisation to adapt to changing situations (Merton, 1957; Blau, 1963; Crozier, 1964). In Chapter Five it will become clear to the reader that, whilst the companies in this study had many of the features of formal organisations such as formal procedures, definitions of responsibilities of office holders, hierarchy of super- and sub-ordinate positions, rules were rarely so rigid to prevent innovation.

(2) See Weber (1949) for discussion of the content and uses of "ideal types".

(3) The average machinery manufacturing plant employed only 85 people in 1871 (Hobsbawm, 1975: 526) and as late as 1895 less than 200 companies had their shares quoted on the London Stock Exchange (Kitchen, 1978).

(4) See Loft (1988: 78 - 80) and Hopwood (1987: 214 - 218) who provide details of the cost systems installed at Boulton and Watt's ironworks and Wedgwood's pottery respectively.

(5) See Chapter One above.

Chapter Three.

3.1 Introduction.

Before the issue of accounting's representation of the financial benefits of FMS may be addressed it is necessary to identify the nature of FMS systems and the economic benefits that stem from their introduction. This is the purpose of this chapter.

Chapter One criticised those approaches that infer the most viable use and economic benefits of FMS by reference to the intrinsic qualities of the system or the long term trajectory of the economy. In the absence of any better method, this thesis proposes to use a company's own definition of their intended deployment of FMS prior to its installation as the best use of their particular system as long as such a deployment meets one condition: that is, that such a use is not precluded by the availability of an alternative, either conventional or new computer-based, system more suited to the economic manufacture of the range and batch size of parts that each company was intending to machine.

It is not possible to define the economic benefits that arise from such utilisations of FMS, and which accounting practices have to express and monitor, in an unproblematic way. As the different theories of long term trajectories discussed in Chapter One imply, there have been two types of production system that FMS may succeed in the manufacturing sector (1). Also, as was argued in the introductory chapter, FMS may be used to pursue different manufacturing strategies that offer some mutually exclusive benefits. The strengths of preceding production systems and the opportunity costs of not pursuing other manufacturing strategies

with FMS will limit both the types of financial benefit that exist for accounting practices to monitor, and, by inference, the potential area of viability of the system.

This chapter will explain the area of batch production, in terms of range and batch size of parts, where deployment of FMS is viable. It will also explain the nature of the economic benefits that different deployments offer which accounting practices are then expected to express and monitor. This will be achieved through: (i) a description of the benefits and weaknesses of the preceding production systems, alternative computer based systems, and FMS; and, (ii) an identification of the types of economic benefits that are likely to materialise from the deployment of FMS in a given context.

3.2 Costs and Benefits of Preceding Production Arrangements.

The financial benefits of deploying FMS are relative to the extent to which a company's existing methods of production correspond with their markets. Further, as argued above, the type of gains that materialise after the installation of FMS are contextual and partly contingent on the preceding method of production that a company employs. The preceding methods of production, thus, provide a useful starting point for explaining the manufacturing strengths of FMS and the financial benefits that are likely to arise from their introduction.

Until recently, there have been only two forms of production organisation employed in manufacturing, mass production and conventional batch production (Gallagher, 1980). Therefore, regardless of their exact manufacturing requirements, companies

have been presented with a dichotomous choice. The nature of that choice has been the attainment of productivity by dedicating processes to single purposes or the realisation of flexibility by letting workers exercise control.

The system of mass production has offered the former. It is comprised of single purpose machinery, flowline organisation and, generally, semi-skilled operators. The nature of each constituent element has evolved out of the pursuit of increased productivity and reduced unit costs. The efficiency that stems from specialisation (see pp 26 - 27, above) has led to the fragmentation of the work process. At each stage in that process machinery dedicated to the same operation has been employed to facilitate maximum output. Companies have generally used the dedication in the machinery to employ lower paid semi-skilled staff to operate the machines at each stage of the work process. The machinery is ordered into a logical sequence that mirrors the chronological order of the operations that have to be performed in the manufacture of that product. This allows work to "flow" through the factory in a rational and efficient order as raw materials are converted into finished products by increments at each successive stage.

A number of different methods may be used to transport the parts between the production stages. These include manual transportation and mechanised belts that allows the item to be removed whilst manufacturing operations are performed (Wild, 1974). However, the exemplary form of conveyance has been the mechanized flow line on which parts are fixed. These may be introduced when the cycle times of each successive work station are aligned with one another so that completion of the work on one part and its

departure to a subsequent stage can be coincided with the arrival of another semi-processed part from the preceding workstation. The rationale for the use of mechanised flow lines that was offered by their pioneers was the increased output that arose because of the elimination of the time taken to move parts (Ford 1923: 80, 88; Arnold and Faurote 1972: 105 - 6, 245). Others have interpreted this as intensification of work by an enforced pacing of production workers (Gartman 1979: 201 - 2). Regardless of which interpretation is correct the mechanisation of flow lines has also increased the system's dedication.

In some factories only the main production processes have been organised along these lines. Subsidiary processes have sometimes employed general purpose machinery and skilled staff. Where demand was greatest the pursuit of efficiency through fragmentation could be extended to subsidiary processes. Thus, as the productivity of the system grows so does its capital intensity and its degree of dedication.

But the dedication in the system often meant rigidity. This carried a number of costs. Firstly, the combination of capital intensity and dedication in the system creates a high degree of risk in the capital investment. Purchase of mass production machinery is only justifiable when companies are sufficiently confident that the demand for their products will continue for the two to three year period that it takes to recover the initial investment (Shaiken, 1985). When markets are either satisfied or lost, it is practically impossible to reconfigure the system and almost certainly cheaper to purchase new machinery. Yet it is often markets for mass produced goods that are most volatile. Consumers

discriminate between similar mass produced items on the basis of their relative price and availability (Murray, 1988).

Secondly, high inventory costs are often incurred. Some of these costs may have been avoided. Companies have often pursued increases in the efficiency of production processes to the extent of neglecting to seek improvements to areas such as loading and unloading (Walker, 1989). This has created unnecessary bottlenecks. However, inventories have also arisen because it is difficult to keep all parts of a rigid system of production synchronised with one another (Oliver, 1990). Technical advance or breakdowns in the main areas of the production process are unlikely to take place simultaneous to such events in the subsidiary ones. Thus, cycle times of different processes will not always be synchronised with one another and this creates both the need for, and the source of, "buffer" stocks. Another source of inventory costs has been the disjuncture between demand and supply of products. Mass production ensures the manufacture of a single part at a continuous pace (Chapman, 1975: 470). However, the demand for some mass produced goods such as motor cars is not constant. This leads to stockpiling and ultimately to industrial conflict as companies seek ways of reducing inventories within the confines of rigid production systems (Beynon, 1984: 165).

Thirdly, there are a large number of hidden labour costs. The fragmented processes obviously require staff to co-ordinate them. This was anticipated by advocates of the division of labour such as Frederick Taylor. What was not anticipated was that additional auxiliary staffing costs would arise as a consequence of production operatives being denied the right to exercise discretion over their

work. Shopfloor employees' absence of job satisfaction reduced their affinity with the organisation to a simple instrumentalism (Littler and Salaman, 1984). This has resulted in low standards of work and the need for quality inspectors to ensure that sub-standard goods are detected before despatch (Woodward, 1958: 210). What is more, the geographical concentration of a range of fragmented processes at large single site factories created the collective worker and afforded individuals a certain degree of anonymity. This facilitated trade union organisation, militancy and agitation when employment levels were high (Lane, 1982), and created the need for specialist personnel departments to reconcile shopfloor workers with alienating work conditions in a way that did not disrupt production activity (2).

Mass production systems' limitations have resulted in their use being confined to two types of work: The manufacture of large quantities of identical parts; and the assembly of identical or highly similar products from those mass produced parts (Gallagher, 1980: 73). In other areas of manufacturing batch production systems have been employed.

When perceived in terms of its relationship to productivity and flexibility, batch production provides a mirror image of mass production. It employs highly versatile staff, machinery and organisational layout at the expense of inefficiency and high cost of unit output. For example, 80 - 85% of the time that a part is on a machine is taken up by positioning, loading and guaging (Williamson, 1972: 142). Also unit costs for parts machined by conventional batch production methods are between 10 - 30 times higher than those for goods machined by mass production techniques

(Cook, 1975).

The machinery that is used in batch production is general purpose. In other words, it is able to perform the same type of machining operations such as milling or turning on a range of different parts. This gives the system a high degree of flexibility (Turner, 1970: 88) and reduces capital risk (Gallagher, 1980: 74). Systems are staffed by highly skilled personnel who have to reset the machines as the shape, size and material of the required parts changes.

Batch production utilises the same functional layout that it has relied on since the start of the century (Williamson, 1967/8). Machines are grouped together in discrete areas of the factory according to the function that they are able to perform, such as grinding or milling. The normal practice is for parts to be released into the factory in the exact quantity in which they are required. The same operation is performed on the entire batch before it is moved on to the next stage (Gallagher, 1980: 74). As there is no dedication in the form of conveyance employed between work stages, particular batches may bypass different functions, or follow different orders, depending on their manufacturing requirements. New batches may be prioritised and machined out of sequence despite other work being in process before them.

Despite its flexibility batch production is not without its diseconomies and unintended costs. Firstly, as in mass production, large inventories have been carried, albeit for different reasons. The completion of a whole batch before transportation, the time taken in set-ups and the holding of some batches when prioritised ones are machined, all contribute to a part only being on a machine

5% of the time that it spends in the shop (McBean, 1982). This in turn generates a second set of costs. Auxiliary staff are required to schedule, monitor and transport work as it progresses through the shop (Bessant and Heywood, 1985). Thirdly, and as was noted above, machine utilisation is extremely low because of the time taken in set-ups, loading and positioning of parts. Finally, and most importantly, direct labour costs are extremely high. Jaikumar reports:

"For custom and small batch production, the cost of a product is predominantly attributable to labour, and unit costs do not decline much with volume. Since each job is unique, the set-up requires the active involvement of a skilled machinist." Jaikumar (1984; 7)

Conventional batch production is, thus, most suitable for those companies that build nothing but prototypes and who are able to exploit the full extent of the flexibility of resources. The restricted number of options, of either mass production or batch production systems, has meant that firms have been confronted with a straight choice of pursuing either flexibility or productivity. However, markets have demanded a wider range of parts than that which mass production and conventional batch production industries have been able to supply when operating at optimal performance. The greater variety in the size of markets for different products has led companies to experiment with the organisation of systems. They have attempted to align output from their manufacturing system with the demand for parts other than prototypes or mass-produced standardized items. Most of these experiments have taken place in the area of batch production because of the rigidity in mass production systems. One such modification was the development of

Group Technology (GT).

GT refers to the arrangement of groups of machines into self-contained cells in place of functional layout. The cells may be used to perform all the operations necessary to manufacture a range of similar components that belong to the same family, as measured by their similarity in shape and size. GT's simplified flow of parts facilitates a reduction in inventories (Blackburn et al., 1985).

The major advantage of this new arrangement, however, is the increased utilisation of labour and machinery: As tools, fixtures, gauging and inspection are all standardised the same operation may be performed on all of the parts in a family at a single point in time. This reduces the number of set-ups required and increases output from both machines and operators. In this respect Group Technology moved batch production towards the economies associated with mass production. However, Blackburn et al. (1985) warn against such a simple interpretation. There are a number of important variations between the integrated systems based on cellular organisation and the dedicated flowlines discussed above. In the former: (i) parts are produced in smaller batch sizes; (ii) a greater variety of pieces are machined; and, (iii) workers generally continue to exercise a wider range of skills and this facilitates continued flexibility.

The introduction of Group Technology did, however, carry its own diseconomies which limited its appeal. It compounded the problems associated with scheduling by necessitating that different batches from the same family coincide with one another. So although it was initially adopted by about 10% of firms in batch production

(Littler and Salaman, 1984) some of the companies subsequently reverted back to functional layout (Swords-Isherwood and Senker, 1978).

Another way by which companies in batch production have sought to reduce the high levels of unit costs has been by the development of manufacturing strategies that aligned the deployment of their machine tools to the pattern of demand for their products. New and Myers (New, 1976; New and Myers, 1986) distinguish between systems that are used for "made-to-order" and "made-for-stock" manufacture. "Made-to-order" refers to companies waiting until they receive definite orders from customers before producing each item. This is the conventional form of batch production. Whilst labour and machine utilisation are low and unit costs are high, these are subsidiary considerations for both producer and consumer. The key performance criteria are how quickly a company can produce to their customers' specifications and whether or not they can be relied on to keep their promises.

In contrast, when a company adopts a "make-for-stock" manufacturing strategy, they aim to reduce unit costs by machining parts in larger batches to improve the levels of machine and labour utilisation. As New and Myers point out, companies pursuing these strategies do not fall into two distinct groups. A large number of firms pursue a combination of both strategies and use the same production facilities to "make-for-stock" and "make-to-order": That is, they sometimes buy raw materials in advance and manufacture when receiving orders. Alternatively, they machine parts in advance and assemble when firm orders are received. However, such a strategy leads to a proliferation of inventories at key points in

the company's manufacturing process.

One final modification that was made to conventional batch production was a change to the machinery employed. This involved the development of Numerical Control (NC) machine tools. Each conventional machine tool had been staffed by a highly skilled setter/operator. These were responsible for manipulating the numerous cranks, shafts and levers to guide the different tools along their different axes and machine each batch of parts into the desired shape. The operator would then reset the machine in preparation for the next batch. NC refers to a program in the form of a paper or plastic tape that contains coded numerical information. This is placed in the head of the machine tool and directs the different operations that have to be performed in the course of the machining of a part. Initial capital expenditure is increased because of the facility for storing a program but subsequent operating costs are reduced: Levels of utilisation are ensured because the machine is directed by the tape which will have a more regular pattern than the operator. Thus, increases in productivity are achieved without jettisoning the flexibility in conventional batch production. However, flexibility has been compromised where companies have installed several NC machines and sought to reduce labour costs by introducing a division of labour between a small number of skilled setters and a larger number of lesser skilled operators. The overall impact of this development appears to have been minimal. For example, by 1976 when the concept of FMS was being developed, NC represented only 1.32% of all metal-cutting machine tools in Britain (Iredale, 1977).

The consequence of these developments in batch production has

been to bring some modification to the preceding dichotomy of productivity exclusive to mass production systems and flexibility exclusive to batch production by making the latter more productive.

In summary, what has been explained here is that two forms of technical and organisational systems of production have preceded the development of computerised machine tools in the manufacturing sector. On the one side there have been Mass Production systems which used mechanised processes to guide production operations. This has offered companies the benefits of high productivity at the expense of high rigidity. The alternative has been conventional batch production which has relied on highly skilled personnel to guide production operations. Companies have only been able to benefit from the latter system's flexibility at the expense of inefficiency.

Rigidity and high capital risks or low levels of output and machinery have not been the only drawbacks of the respective systems. Both systems have, hitherto, incurred the costs of high inventories and indirect labour. Despite their weaknesses the systems are suited to the constant production of a single part or the machining of one-offs and prototypes respectively. But the pattern of demand for parts has been more varied than this. Thus, a degree of disjuncture has existed between the pattern of demand from markets and a company's manufacturing facilities. Companies in batch production have tried to remedy this by re-organisation of their work systems, the employment of manufacturing strategies and the development of NC machine tools. These adaptations have not had a great impact in the economics of production systems and the choice confronting manufacturers has remained, largely, polarized.

3.3 Alternative Computerised Production Systems.

The development of microprocessors allows information to be stored "artificially" on computer programs. This provides companies with a third option to the extant choices of building control over manufacturing processes into dedicated mechanized systems or allowing operators responsibility for direction of all operations. That is, the application of a microprocessor allows control of processes to be built into programs and stored and recalled when necessary to guide particular operations. The ability to adapt machine hardware to different purposes makes computerised systems more flexible than dedicated ones. The ability to co-ordinate effectively the use of different processes makes computerised systems more productive than conventional machine tools. However, microprocessors are not without their own diseconomies and drawbacks. Computer controlled systems are more expensive and less productive than single purpose machines. They are also more costly and less flexible than manually controlled systems. Humans employ a number of tacit skills (Kurstener, 1978) and are able to respond to contingencies as they arise whilst programs only follow instructions which are coded in advance (Dreyfus, 1972; Dreyfus and Dreyfus, 1986; Libetta, 1988). Thus, a space remains for the two preceding polars of conventional batch production and dedicated systems (3). Nevertheless, in the industries where companies have to machine a variety of parts and production conditions and demand are relatively predictable, computerisation offers a new and viable option.

Computerisation may be employed at different levels: machine level; system level; and, theoretically, factory level. However, it

is not necessary to employ computers at all levels. Companies may combine artificial intelligence with dedicated control or human intervention, to maximise either productivity or flexibility at particular stages of the manufacturing process, depending on their needs. The potential for different permutations has given rise to a range of computerised machine tools: Computer Numerically Controlled (CNC) machine tools; Flexible Manufacturing Cells (FMC); and, Flexible Transfer Lines (FTL); as well as FMS. These are more or less suitable for different companies depending on the pattern of demand for products from their markets. The availability of these other configurations limit the area of production where FMS may be employed economically. A brief description of the strengths and weaknesses of these different alternatives will illustrate this point.

CNC is a simple standalone system. It is effectively a NC machine with it's own computer attached. This allows the programs of machining instructions for different parts to be stored in the computer's memory. CNC is more expensive than NC because of the addition of a computer. However, ongoing savings are achieved through increased productivity: The system's computer allows amendments to be made to programs at the machine instead of returning the tapes to a central programming department. Also, local storage of a limited number of programs at the machine tool allows instant recall of the settings for the batches which are machined most frequently. Both of these factors facilitate fast change-overs between jobs and higher levels of machine utilisation. However, as only some of the setting and machining operations are under computer control, tasks such as monitoring of operations and

loading and unloading have to be performed manually. Nonetheless, the degree of computerisation does make it possible for the operative to mind more than one machine. The presence of an operator and the limitation of programming costs to the part itself makes CNC suitable for machining small batch work that is required frequently.

The other new computer based systems link machining centres to a wide range of other facilities and integrate a number of shopfloor operations. The flexible manufacturing cell (FMC) is the smallest of the integrated systems. It has only one general purpose CNC machine tool, but this is supplemented by a workpiece store, transport device and a tool change and storage facility. All of these are under the supervision of a computerised control system. Flexible manufacturing cells are more expensive to purchase than CNC because of their increased size and complexity. The main operational advantage that FMCs offer over standalone CNC machine tools is the ability to machine a limited number of different jobs in rapid succession to one another without any manual intervention. The impact of this is an estimated 50% improvement in productivity (Primrose and Leonard, 1985b). However, both the length of time of the system's unstaffed operation and the complexity of the parts that FMCs are able to machine is limited by the size of the cell. Thus, FMCs are suitable for machining a relatively wide range of less complex parts, when there is recurring demand.

The system which mixes computerisation with dedicated processes is the flexible transfer line. (This is also known as: Direct Numerical Control (DNC) line (Browne *et al.*, 1984); tandem type DNC (Hitomi, 1979); dedicated FMS (Groover, 1980).) It

comprises:

"several automated universal or special purpose machine tools and further automated workstations as necessary, interlinked by an automated workpiece-flow system according to the line principle. It is capable of simultaneously or sequentially machining different workpieces which run through the systems along the same path. In order to balance differences in cycle time, setting times or short faults, buffers may be allocated between the stations." (My emphasis. Warnecke, 1985: 4)

The advantages of FTL's are that they can utilise all of their constituent work stations to achieve high productivity and to machine complex parts. The scope of this complexity is determined by the aggregate of the machining capabilities of the machine tools in the system and is only restricted by their sequential order. The main weakness of FTL systems is the dedication which stems from their uni-directional conveyor. The range of parts that the system is able to machine is limited to those which undergo the same operations in exactly the same sequence. The only alternative to this is to bypass some workstations and lose the manufacturing capacity of some of the system. As FTL's comprise a larger number of workstations than FMC their initial cost tends to be higher. This and their degree of rigidity makes them most suitable for large batch production of a limited range of parts for large and relatively stable markets.

The final configuration of computerised machine tools to have been developed thus far is the flexible manufacturing system. The DTI (1984) have defined FMS in the following way:

"Flexible manufacturing is a system which combines microelectronics and mechanical engineering A central on-line computer controls the machine tools and other work

stations and the transfer of components and tooling. The computer also provides monitoring and information control."

It is of value to elaborate on the constituent parts of FMS. This will highlight that, whilst it may be possible to employ FMS in all areas of production, the sophistication and cost of the system is likely to limit its application to areas not served by the systems already discussed.

Firstly, each system employs a number of the universal type of computer numerically controlled machine tool. These are able to operate along four or five axes which allows each workstation to machine the workpiece from a range of different angles. Secondly, each FMS will have a comprehensive range of tooling. The constituent machine tools are likely to have tool storage facilities of their own which may in turn be linked to the tooling stores of the other machines in the system and/ or a central automated tool store. The range of tooling will allow different parts to be machined in different ways. For example different sizes and depths of holes may be drilled.

Thirdly, a system's transport facility will either have the capacity to move parts from any machine to any other in any order, or along a given route to groups of machines performing similar functions such as milling or grinding, bypassing stages if necessary. The design of the transport system may also embody storage areas or buffer zones so that a batch may be held whilst one centre finishes machining the previous batch or, alternatively, to allow prioritised batches to bypass less urgent ones.

Finally, there is the degree of computerisation in the system. Each constituent element of the FMS will have its own computer that

transmits and receives information to and from the host computer that co-ordinates and supervises the whole process. The host computer will analyse and transmit information such as schedules, machining operations to be carried out, tools required, etc. to ensure that parts arrive at the right time, at the right machining centre with the correct tooling. However, it will react to information from the system's sensory devices that warn of the wear on tools, breakages and other malfunctions. It should, therefore, be possible to load the raw castings of a range of different parts onto the system and the FMS should then be able to carry out all of the constituent processes before delivering the finished part to the unloading station.

Whilst it is possible to design FMS systems that have the technical capabilities of machining parts in permutations of range and batch sizes, FMS is not economic for machining either prototypes and some small batch work or a limited range of parts desired in large batch sizes. Avlantis and Parkinson (1981: 77, see also, Bessant and Heywood, 1985; 33) have argued that the other systems discussed above are more suited to small and large batch production. Thus, financially viable deployments of FMS are limited to mid-variety/ mid-volume production range. That is to say that they are best suited to the machining of a range of between 4 - 50 parts that are required in volumes of between 50 - 2,000. Avlantis and Parkinson (*ibid.*) claim that the other computerised systems are best suited to machining parts in the following range and batch sizes.

	Range	Volume
FTL	1 - 10	1,000 - 10,000
FMS	4 - 50	50 - 2,000
FMC	30 - 500	20 - 500
CNC	200+	1 - 50

In summary, this section has described how the development of microprocessors allows a third option for the control of production processes. Instead of the preceding alternatives of building control into dedicated processes or making labour responsible for direction of work operations companies may use the information stored artificially on programs to direct production. This third option has given rise to a range of computerized machine tool configurations. Each of these have their own respective drawbacks and strengths vis-a-vis the preceding production systems of conventional machine tools and dedicated systems. Whether it is more beneficial for companies to elect computerised systems will depend on the extent to which the potential demand from a company's markets correspond with the range and variety of parts that each system is able to machine economically. Generally, FMS is only viable when a company caters for markets that demand a mid-sized range of parts in medium sized batches.

3.4 The Costs and Benefits of FMS.

If after considering the other manufacturing options a company's staff considers that FMS constitutes the system that corresponds most closely with the demand for the company's products, they still have to justify their investment in that system. However, because of their degree of complexity, FMS systems are expensive. When the majority of the systems surveyed in the course of this study were purchased in the early and mid-1980s,

American estimates put the cost of a full-scale FMS encompassing computer controls, five or more machining centres and the accompanying transfer robots, at around \$25 million. In comparison, a rudimentary flexible manufacturing cell built around a single machine tool was priced at around \$325,000 and a conventional turning NC machine was priced at about \$175,000 (Bylinsky and Moore; 1983). In effect FMS can be more than 75 times more expensive than the former and over 140 times more expensive than the latter. It is, however, possible to purchase more cheaply. The cost of FMS systems covered by this study ranged from about £500,000 to £10 million.

Yet despite the system's high cost, the continued existence of the preceding systems and the availability of alternative computerised machine tool configurations a number of authors have claimed that the potential constituency for economic deployment of FMS will grow because of the system's capacity to exploit the strengths and remedy the weaknesses of both conventional batch and mass production. For example, Meegan (1988) has argued that FMS will bring the benefits of batch production to mass production systems. He says:

"With flexible manufacturing systems firms can shift production scale without any significant impact on overall operating costs - enjoying in the process what have come to be called economies of scope. These economies thus augment the economies of scale (the reduction in cost per unit of output) that the manufacture of standardized products in long production runs offer." (Meegan, 1988: 167. Original emphasis.)

Conversely, the DTI (1984) have argued that the use of FMS will spread not by bringing the advantages of flexibility to mass production but because the "combination of flexibility and overall

control" in FMS "makes possible the production of a wide range of products in small numbers" and brings "economies of scale to batch work".

Both of these claims tend to embody assumptions akin to those in theories of long term trajectories. Meegan's arguments, like those put forward by Jaikumar and Piore and Sabel, suggest that opportunities for economies of scale are in some way safe or no longer relevant. By contrast, the DTI, like the Neo-Fordists and Labour Process theorists are suggesting that there is something inherently superior in the principles of mass production. Any movement in their direction, thus, outweighs any costs incurred. It is these types of assumptions that this thesis objects to. As indicated above, regardless of any change in the direction of the economy, parameters to the areas where FMS may be employed economically are set by the availability of other computerised systems, more suited to machining economically parts that are required in particular range and batch sizes. What is more there are opportunity costs incurred when FMS is deployed. As intimated above, computerised systems may be more flexible than dedicated machinery and more productive than conventional machine tools, but they are also less productive than the former and less flexible than the latter. Further, some gains may not materialise as a consequence of a company pursuing a particular manufacturing strategy with their FMS. The limited benefits that may arise from the deployment of FMS may be understood through a detailed disaggregation of the types of financial advantage benefits that have been claimed for the system.

One employee of a major machine tool company (Klahorst, 1983)

has proposed the following 14 point checklist of the potential savings which stem from the installation of FMS.

- * Direct labour costs: These are reduced because of the greater number of personnel that are needed to staff conventional systems.
- * Machine-setup costs: Reductions are achieved because it takes a greater length of time to reset a conventional machine after each batch has been machined.
- * Tooling costs: More time is taken in locating tooling in conventional machine shops which also incur greater costs because tools are stored in separate areas in conventional machine shops.
- * Materials handling costs: Conventional shops incur more costs in moving parts between conventional machines and also have to maintain the equipment used for this purpose.
- * Part-inspection costs: Automated part inspection with FMS eliminates the need for separate inspection.
- * Equipment-maintenance costs: Automated systems give early warning signs of such factors as tool wear and, therefore, reduce the need for subsequent repair.
- * Shop-supervision costs: The larger size of conventional shops and the greater number of machines necessitate a large number of supervisors. This is reduced with FMS.
- * Production-control costs: The integration of operations reduces the need for shop scheduling and part dispatch.
- * Manufacturing-engineering costs: The incremental tooling and machine costs involved in changing equipment to new uses are reduced.
- * Plant-facilities costs: The smaller size of integrated systems reduces the amount of space that is required.
- * Inventory costs: The integrated nature of new systems reduces the number of intermediate points where inventories accumulate.
- * Fixturing costs: The large number of machines required in conventional shops means that there are more fixtures to be stored and maintained. These are reduced with integrated systems.
- * Prototype and new-part costs: The staffing and machine costs incurred in introducing new parts are reduced with FMS because of the increased ease of transferring synergies.
- * Rework and scrap costs: These are reduced due to the greater reliability of computerised systems.

Other advocates for deployment of FMS have suggested other gains will also be achieved. These advantages include:

* **Reduced Capital Costs** (Primrose and Leonard, 1984; ILO, 1983): The higher levels of machine utilisation that are obtained from integrated systems and their adaptability to new uses leads to a reduction in the number of machines required and a reduction in overall capital costs.

* **Faster Payments** (Shewchuk, 1984): The reliability that stems from the introduction of FMS leads to customers paying up earlier and improves a company's cashflow and liquidity.

* **Increased share of markets**: Companies ability to vary the range of goods which they machine (Jaikumar, 1984) and their earlier delivery times due to the reduction in lead times allows them to capture new markets (Shewchuk, 1984).

In addition to the benefits that the systems bring, national Governments have introduced schemes which provided financial assistance to those firms that have introduced FMS (3).

In the light of the description given above of conventional batch production and mass production systems, it is easy to see how the cost of prototypes are reduced where mass production systems had been employed previously. However, this seems a less convincing proposition when considering conventional batch production. Whatever synergies are transferred, some changes will have to be made to some machining processes and scheduling of parts, etc. and some new programming costs will have to be incurred. These are unnecessary in conventional batch production. Similarly many of the other gains such as direct labour, fixturing costs and capital costs may fall if conventional batch production had been employed previously, but are likely to rise if the companies had utilised mass production techniques.

The extent of some of the advantages that accrue to FMS may also be limited by the objectives which the company seeks to

realise when deploying their system. It will be recalled from Chapter One of this thesis that three manufacturing philosophies were outlined. These were "Mass Production", "Flexible Manufacturing" and "Just-in-Time". The qualities of FMS allows pursuit of all three of these objectives to varying degrees. The speed at which FMS may be changed over to produce different parts allows high levels of machine utilisation and reductions in direct labour costs which are associated with "Mass Production" objectives. The computerised nature of FMS allows it to be used to machine a wide range of parts which is associated with "Flexible Manufacturing" objectives. Finally, the integration of processes and the ease of changeover to machine different parts allows the company to machine in the batch size that it requires parts and prevents the build up of stocks between different processes. This leads to reductions in inventories which are compatible with "Just-in-Time" objectives.

As explained in Chapter One, there is a tension between each of the three philosophies. At a given point there will be a trade-off between the gains realised from pursuing one objective and loss of gains associated with one or both of the others. For example, inventory reductions will be compromised if companies want to utilise their system at all times in pursuit of "Mass Production" objectives regardless of levels of demand. Flexibility gains are compromised if companies only carry the materials that are necessary to machine the parts in their existing range and for which they have firm orders. There is a similar trade-off between realising a strategy of "Mass Production" which entails maximising machining time in pursuit of high production output and the

possibility of realising "Flexible Manufacturing" objectives and producing the widest range of goods. Yet some advocates of FMS have claimed that marked gains in all areas may be realised. For example, the Institute of Production Engineers (1986) have claimed that new parts may be introduced onto systems which realise 73% reductions in inventories and a system utilisation of 95%. This is not borne out by this research. To anticipate the discussion in the subsequent chapters, companies that either introduced new parts onto their systems, or sought marked gains in inventories, rarely expected or achieved levels of utilisation of 90% or above.

It should also be stated the scale of many of the claimed advantages of FMS have often proved optimistic and difficult to realise in practice. For example, capital and plant reductions may not be that significant. One survey found that 66% of installing firms overspent on their initial capital cost projections (Kochan, 1984). Space reductions are often immaterial because companies do not have alternative uses for the area (Bessant, Bowen, Dickson and Marsh, 1981, cf. Littler and Salaman 1984: 97). Furthermore, anticipated levels of machine utilisation of the new systems assume ideal conditions. The likelihood is that "this will be compromised by breakdowns, resetting requirements and problems in planning and organisation" (Ebel: 1985). It is also likely that using the same hardware for different purposes will not have a significant impact on overall costs as software costs will continue to rise. The application of microelectronics to devices suitable for industrial uses, such as batch production machine tools, tend to be user specific, concentrating programming and development costs at individual firms. As a consequence software costs may eventually

outstrip hardware costs by a margin of 8:1 (Bessant, Bowen, Dickson and Marsh; 1981).

In summary, FMS systems are expensive. Despite this, some authors claim a potentially wide constituency for these systems because they promise the original benefits while alleviating the costs of both mass production and conventional batch production systems. It has been argued here that these gains are often overstated. Practical problems often prevent gains from being realised. Most importantly, advocates also fail to recognise that the potential for any economic benefits are bound within limits by the preceding production arrangements, cheaper alternative computer based systems and a company's manufacturing strategy when introducing FMS.

3.5 Conclusion.

The objective of this Chapter has been to describe the area where FMS systems may be employed economically and to detail the advantages that such deployments offer. It has been explained that, generally, it is only possible to realise economically viable production with FMS when machining a mid-variety range of products in medium sized batches. The financial gains that arise from such uses are relative to the weaknesses in the preceding production arrangements and the possible pursuit of a particular manufacturing strategy. Now that the issue of the financial benefits of FMS has been explained it is possible to assess the criticisms that accounting practices are failing to recognise those benefits. This is the objective of the next Chapter.

Footnotes.

(1) It is appropriate to reiterate here what was stated in Chapter One. That is, that theories of the long term trajectories present accurate accounts of the merits and drawbacks of the two systems. The objection raised in this thesis is not that these two forms of production have not existed but how their existence has been used to theorize the trajectories.

(2) The employment of semi-skilled workers is by no means a prerequisite of mass production. It is just more likely. In the course of the 1970s the problem of disaffected workers in mass production industries did lead to some experiments in re-organisation of the line and the extension of shopfloor operatives responsibilities. However, such experiments were confined to a small number of companies. (See, Littler and Salaman, 1984: 81 - 90, for details.)

(3) What is being argued here is that economists' notions of economies of scale are still applicable in some circumstances. It is not the view of this author that any type of moral case can be made for the de-humanising forms of work that have often accompanied the pursuit of such economies. There are also strong economic arguments against "Fordist" types of methods. As explained above, they are often accompanied by many diseconomies.

(4) In Britain, the AMT scheme, which allowed companies that were installing any type of computer based systems to apply for grants, was succeeded in 1981 by the FMS scheme. This directed Government support at those companies that installed FMS. It allowed companies to claim grants towards the development costs and costs of all necessary capital equipment associated with installing a brand new system or towards the incremental costs of reconfiguring existing equipment (Sims, 1983). From 1981 the amount available was 25% of the costs incurred and in 1982 this was increased to one-third. The Government made available £60 million for the scheme and announced that no new funding would be made available after that money had been spent (FMS Magazine, 1985). By the end of 1987, 98 companies had been offered assistance under the scheme and 87 firms had taken up the offer. At that point £40 million had been committed by offering companies assistance although another £20 million had been offered to companies that had proposed to install industrial robots. (DTI, Private correspondence, November 1987.)

Chapter Four.

4.1 Introduction

The main objective of this research is to investigate whether cost control discourages the best use of FMS by its failure to recognise the expenditure and output profile associated with that deployment. This thesis has argued that the deployment of FMS must be perceived as the culmination of a process of technical change and that pre-investment justifications are employed earlier in this process. These provide a forecast of a company's future economic behaviour that cost control is then expected to enact. As biases are reported to exist at the pre-investment stage (Primrose and Leonard, 1984a; 1984b; Primrose, 1988) their impact must be investigated if the influence of cost control is to be isolated.

The objectives of this Chapter are to describe how the qualities of accounting practices are alleged to discriminate against the introduction and deployment of FMS for given types of purposes and to assess the validity of these claims by reference to the hitherto evidence. This chapter does not challenge the arguments that there is a divergence between the logic and categories in accounting practices, as explained by their critics, and the patterns of expenditure demanded for certain types of deployment of FMS. Thus, there may be the potential for FMS to be misused if accounting practices were to be employed in the way described. However, it will be argued that the validity of these arguments are undermined by their advocates failure to: (i) explain how it is possible for accountants to impose inappropriate criteria on a new system that they have no knowledge of; and, (ii) identify how the actual use of FMS differs from that which was initially

intended by the installing companies. This chapter will progress from a brief discussion of the nature of accounting through an examination of the mechanics of specific practices, their alleged biases and a report of the existing evidence of their impact on the deployment of FMS. Once the nature of accounting practices and weaknesses have been addressed it will then 'e possible to turn to the findings of this study.

4.2 The Nature of Accounting.

In her history of cost accountancy in Britain, Loft describes the practice of accounting as:

"the translation of records concerning diverse objects and events into a common terminology, that of money" (1988: 39 - 40)

In effect, it is a system of representing objects and events by their financial values. The medium used, money, has value inside and outside of a company. This allows a company's personnel to convert objects and events from the outside world into the firm and vice versa. The company is, thus, able to conceptualize a scenario that entails the purchase of a system and its use to manufacture parts for sale in the market. The rules of mathematics and binary algebra can then be employed in advance of that scenario taking place to calculate whether the positive values of the anticipated changes in the company's performance outweigh the cost of purchasing the system. The calculations provide the bases of pre-investment justification techniques. If a decision is taken to enact a change the initial calculations can be used both to communicate to staff the financial or physical standards of performance that are expected from them and, to subsequently

measure how well they are performing. This provides the essence of cost control. However, different authors have argued that: (a) pre-investment evaluation techniques fail to express accurately the existence and extent of some of the dimensions of performance of FMS systems; and (b) post-installation cost control makes inappropriate assumptions of proportional relationships between the different dimensions of performance of FMS systems. This results in FMS either not being introduced in the first instance or, if installed, not being deployed for their most advantageous purposes. The mechanics of the different practices and the validity of the criticisms made will be examined in turn.

4.3 Pre-investment Justifications (1).

There were two main types of pre-investment appraisal technique used at the companies visited in the course of this research: Payback and Discounted Cash Flow (DCF). Of the two methods payback is the oldest, easiest and least expensive to employ. Its application entails quantifying the gross savings that stem from the introduction of a new system over the time allowed for recovery of the investment or "payback period". This is generally two years. If the savings, or incremental gains over other alternative new systems, are greater than the cost of purchasing and installing a new system, or the incremental cost of purchasing the alternative system, the purchase goes ahead. If no such returns are promised, the investment will be rejected. The merit of employing payback to assess the value of a prospective investment is that if the proposed system meets the payback criteria rapid recovery of the initial expenditure is realised.

This is essential when there is an element of risk to the investment (Robson, 1979).

Payback originates from a time when companies were only involved in one line of business. The different effects of competing investments on a company's overall profitability corresponded with the respective levels of improvement which each brought to the single production process. Directors' comparisons of different payback periods were, thus, an adequate measure of the value of the investment to the company as a whole. Since that time there has been the development of corporate forms of organisation and companies have multiplied their product range. It is now more difficult to measure the relative effect on overall profitability of alternative items of expenditure in the different areas of a company. As a consequence, criticisms have been made of payback techniques from within accounting circles.

The general drawbacks of payback methods are: (i) they do not examine the opportunity cost of an investment as payback ignores the benefits that might have been realised had the same sum been invested elsewhere in the company; (ii) the true value of competing investment proposals are not calculated as payback ignores the period after the initial two years when returns are likely to be generated; and (iii) the changing value of money over time will distort the value of the cost of the system vis-a-vis the returns generated up to 24 months later. These weaknesses in payback led to accountants developing DCF techniques, after they had first assimilated economists' concepts of inflation and opportunity costs (Parker, 1969: 17 et seq, 59).

DCF is considered to be a superior method to payback because

it embodies the concept of the opportunity cost of pursuing one investment rather than another and recognises the changing value of money (Sizer, 1975). The application of DCF demands that the company estimates the future cashflows that stem from investment in a particular piece of equipment over the course of its assumed lifespan. This should include the total incomes for each year including revenues from sales, tax concessions, investment grants and any scrap value that remains after the equipment has exceeded its useful life. The present value of the returns that accrue in future years is determined by multiplying the current value by the discount rate (2). The firm can calculate the sum of profit by deducting the cost of the initial investment from the aggregate of income generated. The rate of profit is calculated by dividing the aggregate profit by the sum of investment. Where alternative proposals are being considered the firm will decide which investment promises the best return and invest accordingly. It is the comparisons of potential rates of profit that embodies the notion of opportunity costs. DCF appraisals are more expensive to conduct than payback and yet they often offer no marked differences in recommendation (Robson, 1979). This is an important reason for the continued use of the latter method.

There are clearly variations in the methods of payback and DCF. However, the initial calculations in each should include determining the value of the output that a system's capacity can manufacture, quantifying any additional advantages that accrue from employing the system and assessing whether the total of these over the system's lifetime outweighs the cost of its purchase. Broadly speaking there are three types of criticisms that are made of how

such an assessment discriminates against FMS systems. Firstly, accounting techniques tend to understate the potential capacity of FMS. Secondly, pre-investment appraisals do not recognise the full range of the benefits that FMS brings. Thirdly, pre-investment appraisal techniques understate the FMS system's lifespan. The authors that put forward these arguments claim that these weaknesses discourage companies from introducing FMS. However, this thesis is concerned with explaining the influence of accounting practices on the eventual pattern of deployment of FMS. It will, therefore, extend these arguments to show that as the pre-investment justification generates expectations of the post-installation performance of systems, the alleged weaknesses in pre-investment justifications may also be perceived as having the potential to direct FMS towards large volume production of a limited range of parts, if systems are installed. The nature of each of these alleged failings will be considered in turn.

(i) Definition of capacity of FMS used in pre-investment justifications.

New production equipment is generally installed to provide either replacement or additional capacity for known markets. The pre-investment justification, therefore, assumes the system to have a specific and consistent use. The value of the system is assessed with that use in mind. Capacities of conventional, dedicated systems are known but, as was explained in Chapter Three, these may be rendered redundant by changes in markets because the system cannot be adapted to new uses. FMS, by contrast, are plastic systems. They may be adapted to the specific needs of individual

firms and their potential uses may be proliferated over time. As a consequence FMS have a more pronounced learning curve and are unlikely to realise their full potential capacity for a number of years (Charlish, 1983). This particular weakness in pre-investment justifications is most likely to discourage the deployment of systems that are introduced to manufacture the widest ranges of parts. This is because this type of deployment is most likely to have the highest cost, realise lowest capacity at the outset when development work is conducted, but will also enjoy the greatest additions to capacity in the long term. Alternatively, by setting expectations that returns will be constant throughout a system's life, this weakness in pre-investment justifications may encourage a company to use whatever system they do introduce for large batch production of a limited range of goods, regardless of the company's intentions when introducing the system, as it is this use which is most likely to facilitate realisation of constant levels of output from the outset.

The definition of capacity espoused by pre-investment justifications is also deemed to be biased against the introduction of FMS because it fails to recognise the systems capability of gaining physical capacity. Extra machine tools may be added to the configuration and, unlike with conventional machinery, the existing computer facility allows these additions to take place without a parallel increase in the price of the system (Charlish, 1983). Hayes and Jaikumar express this in the following terms:

"factories are often modernised through a series of independent projects, each justifiable in its own dollar terms until, eventually, a way is found to link these individual islands of automation into a

profitable whole.

Unfortunately, this approach is often not appropriate when moving toward computerised automation. No one component of a CIM network - a parts rationalisation system, a CAD system, an FMS, a plant-floor data collection and information system, or a customer communication system - may be able to meet a company's profitability requirements. The desired returns materialise only when all these advances are in place." (Hayes and Jaikumar, 1988; pp 81.)

This weakness in pre-investment justifications is likely to affect all proposed FMS systems regardless of their intended use.

With reference to the first argument, it is difficult to perceive any logical reason why the personnel responsible for composing pre-investment justifications cannot report gains in the range and value of parts produced. However, as there is no empirical evidence to support or refute this argument it will be given further consideration in the latter part of this thesis.

It is possible to offer a more conclusive rebuttal of the second argument. Disproportionate increases to the sum of physical capacity vis-a-vis the cost of purchasing the hardware are unlikely to materialise. Many firms are organised hierarchically with investment initiatives originating from a number of separate departments (Jones, forthcoming). Thus, systems are introduced as discrete projects rather than as a movement to CIM (Bessant and Haywood, 1985: 1987). No-one in the firm has a perspective on how benefits could stem from integration (Finnie, 1986). The absence of such a perspective from the outset often leads companies to install potential components of CIM that are incompatible with one another. They cannot be integrated subsequently (Bessant and Haywood, 1985; 54).

(ii) Benefits of FMS that are recognised by Pre-Investment Justification Techniques.

It was reported in Chapter Three that there are a range of systems which may be used to machine a variety of goods in batches of various sizes. These are often less expensive than FMS. Historically the purpose of introducing machinery was to increase efficiency by reducing labour. (See, for example, Whitmore, 1906.) The extra expense of FMS cannot be justified on the basis of labour savings alone. As reported in Chapter Three, there are a wide range of other gains that may accrue to companies after their installation of FMS. However, locating a new system in a specific area, or cost/ budget centre, encourages personnel to concentrate their attention on advantages that arise in that area when conducting the pre-investment appraisal. Such a myopic focus is inadequate for articulating many of the gains associated with FMS as these arise elsewhere in the enterprise. Most notably pre-investment justifications fail to express: reduced inventory which arise through the integration of different processes and the machining of goods in smaller batches (Hutchinson and Holland, 1982; Hutchinson, 1984; Kriegler, 1984; Primrose and Leonard, 1985a); faster cash turnover due to more reliable delivery dates (Shewchuk, 1984); reduced floor space, better quality and improved response time (Kaplan, 1986); increased market share due to improvements in efficiency (Skidmore, 1986); and the ability to machine a new range of goods or the present range in a new mix as the markets change (Jones and Scott, 1986).

Primrose and Leonard (1984a; 1984b; 1985a; 1985b; 1986; Primrose, 1988) anticipate that unless these "intangible" benefits

are quantified and represented in investment appraisals companies will not invest in an FMS when it offers the best financial returns. Alternatively, they will invest speculatively in an FMS when another type of configuration would be more suited to their needs (Primrose and Leonard; 1984a: 131).

It may also be argued that this failing in pre-investment justifications leads companies to use their systems to produce a limited range of goods in large batches regardless of their initial intentions. In other words, as labour savings are most likely to be realised when large batches are produced the expression and pursuit of reductions in staffing will create a tendency towards the large volume production of a limited range of goods which is not countered by the pursuit of other gains.

There are, however, a number of reasons for questioning the extent to which pre-investment justifications are not representing accurately the potential benefits of FMS. Firstly, some authors may be overstating the potential benefits that arise following the introduction of FMS. It was argued in Chapter Three that some advantages associated with FMS may be mutually exclusive of one another. The realisation of some advantages depends on the extent to which a company intends to use its system for one the three manufacturing philosophies of "Mass Production", "Flexible Manufacturing" and "Just-in-Time". It was also argued that the extent to which any advantage of FMS appears as a gain is relative to the company's preceding production arrangements. Therefore, any inability of pre-investment justifications to articulate certain types of advantages that are associated with FMS must be located in the context of the company's preceding production arrangements and

objectives in deploying FMS. Secondly, there is some evidence that new advantages associated with the manufacturing philosophy of "JIT" are being reported in companies' pre-investment justifications. Jones and Scott (1985) report that in their study of firms that have introduced FMS inventory gains outweighed labour savings in importance. Thirdly, some of the costs, and particularly those associated with "Flexible Manufacturing" objectives, may be being understated in pre-investment evaluations. T.C. Jones (1990b) observes that conventional accounting practices often underestimate the post-installation costs such as software that are associated with CIM. He suggests that this may be perceived as compensation for any tendency to understate benefits.

Clearly, the relationship between the deployment of FMS, manifestation of costs and benefits and their subsequent representation in pre-investment appraisals is a more complex one than critics suggests and requires further investigation.

(iii) Concept of lifetime used in pre-investment justifications.

Most British firms use non-discounting investment appraisal methods such as payback (Parker, 1969; Primrose, Bailey and Leonard, 1984). These lead companies to expect recovery of an initial investment to take place within a limited number of years. As a consequence, payback methods favour less expensive systems which promise easier recovery of the initial investment and discriminate against all expensive systems including FMS. Payback also discriminates against FMS more specifically because FMS possess a number of interactive interfaces that need to be aligned with one another and this takes time. The long gestation period

delays the point from when recovery of the investment takes place, thus, making FMS appear not viable when assessed by payback methods (Primrose and Leonard, 1984a; 1986). This factor can also be perceived to discourage using any system that is introduced for the machining of a wide range of parts regardless of the company's initial intentions because such deployments require the longest gestation period due to their greater complexity.

Authors disagree on whether firms build sufficient length of time into DCF calculations. Primrose and his colleagues (Primrose, Baily and Leonard, 1984; Primrose and Leonard, 1984a; 1984b; 1986.) argue that DCF techniques could be used to redress the problem of the limited life afforded to FMS by payback methods. In contrast to this, Jones (1988; forthcoming) suggests that DCF techniques also understate the amortisation period of FMS. It does not appear unreasonable to argue that as DCF methods calculate returns over a longer period than payback they discriminate less against FMS than do payback methods. However, it may be that DCRs are being set too high (Kaplan, 1986).

International comparisons give prima facie support to the argument that western companies are understating the potential lifespan of FMS. Companies in Japan do not use such short term methods of appraisal as those in the West (Kaplan, 1986). More FMS systems have been introduced into Japanese firms than into companies in Britain or the USA (Bessant and Haywood, 1985: 20; The Economist, 30/5/87: 10). However, there are other possible explanations for national variations in the number of installations. The Japanese system of "Zaibatsu" encourages long term development and investment whilst western style free trading

encourages pursuit of short term goals (Hill, 1981: Jones and Graves, 1986). Any variation in the amortisation period allowed by accounting practices may, therefore, be epiphenomenal manifestations of deeper structural differences.

British studies that have examined the influence of justification techniques on the introduction of new systems have rarely been addressed directly at FMS. Nonetheless, their findings tend to suggest that companies' use of appraisal techniques that measure returns over a short period do not always deter companies from investing in computer based manufacturing systems. Bessant and Haywood (1987) investigated the methods of appraisal that small to medium sized firms in Britain used to justify FMC. They found that 7 out of the 8 companies had been able to justify their investment using payback of three years or less. Woods et al. (1985) researched the techniques used by firms to evaluate the wide range of systems that fall under the umbrella title of CAD/CAM. They also found that over one third (ie, 16 companies) were able to justify their investment using payback. What is also significant about Woods et al.'s findings is that a number of companies introduced their systems without conducting a financial appraisal. (See also: Arnold and Senker, 1983; Arnold, 1985.)

Woods et al.'s findings that accounting criteria are often not deployed as an effective evaluation technique receives some support from two studies that address directly the introduction of FMS. The first is that conducted by New and Myers (1986). They found that two-thirds of the firms that had introduced FMS had received negative payback. New and Myers do not make it clear whether this had been anticipated at the outset or simply materialised after the

system had been installed. Thus, different interpretations may be put on their findings. Firstly, payback methods would be prohibitive if they were employed effectively before the investment took place because sufficient returns cannot be earned over a short period and so payback methods do lead companies to view systems as not viable. Such an interpretation would support the arguments of Primrose and his colleagues. An alternative interpretation of New and Myer's findings is that payback techniques were used prior to the investments taking place but they are of little relevance because companies ignore their conclusions and still invest. If the latter interpretation is correct, accounting would appear to have minimal influence within the enterprise. The findings of the second study are more conclusive. Finnie (1986) reports that some of the companies that introduced FMS using traditional financial justifications were only able to achieve this by managers submitting spurious figures in order to win accountants' approval for the investment. This suggests that accountants have minimal influence in the decision of whether or not to invest. A discussion of the influence of accounting on FMS must, therefore, investigate both the content of the accounting calculations and whether the people responsible for composing those calculations believed them to represent FMS and were capable of using them as such.

Summary and discussion.

Management accounting entails attributing money values to different dimensions of a firm's performance as a means of planning and controlling a firm's expenditure to ensure that a profit is obtained. The pre-investment evaluation techniques of payback and

DCF entail: estimating both the quantities of additional parts that a new system can machine and the nature of other changes to a company's manufacturing performance; representing these by the financial values that will accrue to a company over the lifetime of the system; and, calculating whether these offset the cost of purchasing the machinery. Critics have argued that financial appraisal techniques discourage investment in FMS by misrepresenting the system's value by systematically understating its capacity, potential manufacturing advantages and lifetime.

It has been suggested here that if these criticisms of pre-investment evaluations are correct, the profile of expected system performance that is projected, may result in any FMS system that is introduced being used to machine a relatively limited range of parts, regardless of the company's initial intentions. There is certainly prima facie evidence to support such an argument. For example, FMS systems have been introduced primarily for the machining of large batch work in Britain (Jones and Scott, 1985) as well as in a number of other countries including Italy (Rocca, 1988) and the USA (Jones, forthcoming). But this evidence indicates, at most, a correlative relationship rather than a causal one. Empirical research to support arguments about the weaknesses in pre-investment evaluations is limited. As indicated above, the evidence that is available is rarely located in a context that allows insights into the improvements that new systems offer over a company's preceding manufacturing facilities when deployed for a company's specified purposes. Chapter Six will aim to provide such an account by investigating the motives that companies had for introducing FMS and whether they were able to employ pre-investment

justifications that expressed these objectives.

What is clear from the available evidence is that the composition of some pre-investment evaluations are either consciously (Finnie, 1986) or unconsciously (Jones, 1990b) representing FMS more favourably than is warranted. As the representation of the lifetime of the system, the benefits that materialise from the system's introduction and the capacity of the system are locked together in a single equation, overstatement of one may compensate for underestimation of the others.

This overstatement of the manufacturing strengths of FMS, and accountants' failure to realise this, confirms what was argued in Chapter Two above that management accounting is neither as pervasive nor as omnipotent as the criticisms of accounting practices imply. Indeed, Finnie's arguments suggest the opposite. That is, accounting is actually powerless. However, Finnie's claims, like the arguments of accounting's critics, suggests a clear disjuncture between the content of accounting calculations and the reality that they attempt to represent. Chapter Two above suggested that such a disjuncture was unlikely as engineers who proposed the introduction of new systems and accountants who supervise the application of accounting techniques perform roles that are integral to one another in the process of technical change. Accountants are reliant on engineers to provide them with information about the system that is to be evaluated. As Finnie recognises, this provides engineers with the opportunity to hoodwink accountants. However, that information is then used to compile standards by which the system and engineers are monitored. This should provide protection against deliberate subterfuge.

Chapter Five will elaborate on how this relationship between accountants and engineers, and any divergences from it, is manifest in capital sanctioning route.

4.4 Post-installation cost control.

Cost control monitors the performance of manufacturing systems against appropriate standards to ensure that financial performance is as anticipated. When new systems are introduced those standards are derived from the projections in pre-investment justifications. Thus, whatever uses companies expressed for their system in the pre-investment justification, and any biases in the techniques used, would be embodied in standards of cost control.

There are two main forms of cost control, audits and ongoing cost monitoring. Audits provide a single retrospective picture of the performance of a system over a long term period. Ongoing cost monitoring is the everyday husbanding of resources to ensure that in each short-term period, expenditure and manufacture is at the rate anticipated. Critics argue that ongoing cost control practices assume a constant relationship between expenditure of resources and output. It then seeks to ensure that that relationship remains constant. This is alleged to introduce new biases at the stage of post-installation cost control. These claims will be explained in more detail below. First the influence of post audits will be considered.

Post-audits.

The post-audit is used at a single point in time to measure and report the performance of a system along the parameters built

into the initial appraisal. For example, the levels of staffing and tooling costs will be compared with those anticipated at particular levels of operation. Audits may be carried out by the staff responsible for introducing the system, or by others as a form of combined check on the performance of the machinery and the individual who initiated its introduction. The time and the form of an audit will vary according to the purpose that it is expected to meet. For instance, if the objective is simply to check that expenditure has not exceeded the original budget or to identify the area where expenditure did exceed forecasts, the check may be performed immediately after the system's installation. If the aim is to assess whether the rate of return or the length of payback matches that which was originally anticipated, the audit would be carried out at the end of the project's useful life. Regardless of the designated goals, once any form of audit or appraisal has been conducted, and the systems performance is perceived as satisfactory, further audits are unlikely (Gadella, 1985).

The critics of current accounting practices have not subjected post audits to the same close scrutiny as other forms of cost control. This may be because, as several authors have argued, post audits of FMS have only rarely been performed. Several reasons have been given for this including: FMS are too recent an innovation for audits to have been performed on them (Yates, 1986); the project champion whose status and career may be at stake has a vested interest in post-audits not taking place (Bessant and Haywood, 1987); and, companies do not have the mechanisms for recording the non-productivity gains. Finnie (1986) reported that 20 of the 22 companies in his study had not developed any techniques for

assessing the non-productivity gains of FMS. Nonetheless, audits could highlight where actual performance diverges from that which was projected and whether this has been to the advantage or disadvantage of the company. This could provide valuable information for both advocates and sceptics of the merits of FMS. The failure to evaluate the impact of audits on FMS is, therefore, a notable omission which this thesis will seek to remedy.

Cost Control.

Chapter Two explained that budgets of different types play an important role in ongoing cost control: Companies identify their anticipated output for a given year and the resources that each department would require to meet those objectives. The money required to purchase these resources is then allocated to a department's budget. Although this sum is likely to be linked to projections of the pre-investment evaluation, in subsequent years the determination of the budget will be a subject of negotiation (Otley, 1989; Roberts and Scapens, 1990).

One of the ways that companies can seek to ensure that departments keep within their budget is by defining what the expenditure of one of the inputs should be to obtain given output levels. Both the level of expenditure of that input and the volume of output are then monitored on a regular bases to ensure that they remain reconciled with one another. It is this practice which is alleged to result in FMS being directed towards the undesirable end of large volume production of a limited range of goods (Jaikumar, 1984; 1986; Jones and Scott, 1986; Skinner, 1986) The tendency towards productivity is often accentuated by payment systems that

reward workers for high output (Wheatley, 1989). The validity of each of these claims will be examined in turn.

(i) Input-Output Measurement.

Although there is some variation in the criticisms made of cost control, the general argument of the different writers is as follows. The input-output measurement assumes a constant relationship between the two. Input is measured in terms of either labour hours employed (Jones and Scott, 1986: 7; Skinner, 1986: 57), or level of machine utilisation (Jaikumar, 1984: 23; 1986: 71). Output is measured in terms of volume of output (Jaikumar, 1984: 26; Jones and Scott, 1986: 7). A quotient which gives an indication of the performance of a system is determined by dividing the output by the input. Any variance from that level is considered unacceptable (Skinner, 1986: 57). The consequence of this is an emphasis on high levels of productivity from a system (Jaikumar, 1984: 26; 1986: 71). In the absence of any development of flexibility measures (Kaplan, 1983: 693) systems are directed toward the production of a limited range of goods in large batch sizes.

There is a clear logic in this argument. Accounting calculations that assume a constant relationship between resources are likely to lead to undesired consequences if no such relationship should exist in the deployment of FMS. Jaikumar offers a comparison between the use of FMS in USA and Japan to support the above arguments. In the former, the restrictive cost control practices are employed, whereas, in the latter, cost control practices do not concentrate on minimising labour costs or

maximising machine uptime. Jaikumar found that: on average, only ten parts were machined on US FMS systems compared to 93 in Japan; the annual volume of each part produced in the US on an FMS system was 1727 compared with 258 in Japan; and, the number of new parts introduced onto an existing FMS each year was one in American firms compared with 22 in Japan (Jaikumar, 1986). Other surveys of FMS confirm Jaikumar's findings that Japanese systems are generally more flexible than those in the US (Bessant and Haywood, 1985; Jones, Forthcoming).

But, again this evidence only indicates a correlative relationship rather than a causal one. The latter would require evidence that western companies had intended machining a comparable range of parts to that machined by Japanese systems but had not done so because of cost control practices. Jaikumar fails to establish this. Further, the case of Japanese companies can be used as supportive of alternative arguments. As reported in Chapter One Jaikumar's research found that Japanese systems were not only more flexible than those deployed in America they were also more productive. Finally, like their counterparts who criticise pre-investment justifications, critics of cost control methods claim a disjuncture between accounting practices and engineering systems that this thesis has suggested may not be possible. If such a disjuncture did exist these authors would have to address themselves to a number of other issues which they have not done hitherto. For example, if accounting discourages flexible deployment of FMS how was it possible for FMS systems to be introduced in the first instance? How do accountants define what are low, acceptable and high levels of output from FMS? What effect

do biases in pre-investment justifications have on this? There is clearly a need for research that locates the impact of cost control within the context of a company's motivations for introducing FMS and a more detailed account of the organisation of accounting protocol at a firm.

(ii) Reward structures and employee commitment.

The second criticism of cost control practices is that proposed by Wheatley (1989). He has argued that piecework forms of payment are aligned with volume of output. This leads operatives to actively discourage the use of any system which threatens to reduce aggregate total output and the level of their bonus. Reduced aggregate output may be perceived as a likely outcome if companies were to employ FMS systems for purposes other than the large volume production of a limited range of goods. "Flexible Manufacturing" purposes lead to loss of system time and contingent reductions in output due to the increased number of changeovers necessary to obtain flexibility. Similarly pursuit of "Just-in-Time" objectives might lead to the sacrifice of machining time to protect low inventories.

Wheatley does not address FMS specifically and so does not provide any relevant evidence on the relationship between employee rewards and the deployment of FMS. However, evidence of work organisation in the past suggests reservation of judgement on Wheatley's claims for three reasons. Firstly, workers' responses to performance related payment systems is more complex than simply increasing or decreasing their efforts according to potential levels of bonuses. Money rates for setting and machining operations

generally vary according to the complexity of the process. Operators are aware of this and devise their own strategies to make up time on particular operations to compensate for any unjustified stoppages or lack of speed when machining more difficult work. In this way they ensure attainment of the maximum performance related element of their wages. Even when changes are made to the rates of payment for different parts, workers are adept at achieving aggregate maximum performance over the medium to long term whilst reporting consistent levels of performance over each short term period. By doing this they earn maximum bonus at all times (Roy, 1954; Burawoy, 1979). If workers are able to manipulate representations of their output from earlier generations of machine tools it is possible that they can adjust their strategies to any changes which are caused by different utilisations of FMS.

A second reason for suggesting reservation of judgement on Wheatley's claims is a more straightforward one. Integrated systems such as FMS require fewer staff than earlier generations of machine tools. This is likely to compensate for any reduction in output that might occur from pursuing flexible objectives.

Finally, there does not appear to be any reason to believe that companies cannot adjust their bonus payment systems so that output targets are set less high and other criteria are used to reward workers. Piecework systems in conventional machine shops have generally provided ways of compensating workers for loss of output when set-ups were taking place (Roy, 1954; Burawoy, 1979).

Nonetheless, it is of value to investigate the validity of such arguments by reference to empirical evidence. This issue will thus receive further consideration in the subsequent chapters.

Summary.

Cost control practices are used to ensure that departments perform at levels that are acceptable to the company. When new investments are made these levels are defined in the pre-investment evaluation. There are two main methods for monitoring and controlling the performance of new systems, post audits and ongoing cost control. Writers have either ignored the impact of post audits on the deployment of FMS or simply reported that they have not been conducted. Ongoing cost control techniques have been criticised because they allegedly discourage the use of FMS for providing a range of goods in small batches. Their assumptions of: a constant relationship between the resources of labour or machine time and system output; high productivity being a positive attribute; and, the rewarding of workers for their volume of production; all lead to FMS being used for high volume production of a limited range of parts. International comparisons between the use of FMS in Japan and in western nations are often used to support these arguments. But this evidence does not control for other factors. It views the influence of cost control in isolation rather than explaining its influence in the context of the preceding stages in the process of technical change. Further, it fails to explain how inappropriate standards are defined when novel systems are introduced. This thesis will aim to explain the full significance of these other factors at the firms in this study before discussing the separate influence of cost control on the deployment of FMS.

4.5 Conclusion.

It has been reported in this Chapter that accounting

represents events and objects by their financial values. The specific accounting practices of pre-investment justifications and post-installation cost controls use the rules of mathematics and binary algebra to (i) calculate how pursuit of events and the employment of different resources will affect the wellbeing of the company and (ii) attempt to enact those projections once choices have been made. This chapter has explained how a number of authors have criticised the constitution of accounting calculations for introducing a systematic bias into perceptions of FMS. As a consequence firms are prejudiced against installing FMS or are encouraged to use whatever systems they do introduce for the large batch production of a limited range of parts even though this is to their detriment.

There have been three recurrent themes in the critical evaluation of these ideas that this chapter has offered. Firstly, this thesis has contended that the deployment of FMS cannot be understood simply by focusing on the impact of cost control. The eventual pattern of deployment of FMS is the culmination of a process of technical change. That process includes the accounting practice of pre-investment evaluation of a system. The impact of this earlier stage must be accounted for if the influence of post-installation cost control is to be isolated.

Secondly, that process of change is contextual. The failure of accounting practices to represent and monitor accurately the advantages of FMS can only be understood by identifying the motives that a company had for introducing FMS. Finally, it has been questioned where accounting standards come from. The argument of many of the authors discussed in this chapter is that accounting

practices do not recognise the new dimension of FMS. What they fail to explain is how accountants recognise unacceptable levels of the system's performance when measured along conventional criteria without also recognising the system's strengths and weaknesses.

This thesis will attempt to avoid these weaknesses when reporting the findings of this research in the next three chapters. Chapter Five explains the organisation of engineering and accounting functions around the capital sanctioning route. This will illustrate the opportunity that engineers, who propose the purchase of new systems, enjoy to influence the accounting standards by which FMS is assessed. Chapter Six reports a company's motives for introducing FMS and the success or otherwise they have in overcoming the alleged biases in pre-investment justifications when articulating the benefits that arise from pursuing such objectives. Chapter Seven will then be able to concentrate on investigating the impact of post-installation cost monitoring on FMS.

Notes.

(1) The description of the different accounting practices draws on information from a number of accounting textbooks, in particular: Drebin and Bierman (1978); Robson (1979); Sizer (1975); and, Thornton (1978).

(2) Discount tables are available for firms to employ to establish this. Alternatively the discount figure can be calculated using the formulae $1 + (1 + i)^n$ where i is the rate of discounting and n is the number of years from the time of investment when the income is generated/ received.

Chapter Five.

5.1 Introduction.

It is the contention of this thesis that the eventual deployment of a system is the culmination of a process of technical change. The preceding Chapter has explained that accounting interventions are made at two stages in that process: pre-investment justifications and post-installation cost controls. The former provides the projection which the latter is expected to enact. The arguments made in Chapter Two of this thesis suggest that the ability of accountants to impose their analysis on an engineering system in an inappropriate way at either of these stages is limited by the nature of the accountant's relationship to engineers. That is to say that, whilst accountants enjoy a position of formal superordination over engineers, they are dependent on the latter to provide them with information.

The objective of this chapter is to describe how this relationship between accountants and engineers materialised in the capital sanctioning route at the firms in this study. The chapter falls into two halves. In the first, the normal capital sanctioning route at the firms in this study is described and the nature of the opportunity for engineers to influence the standards by which systems are assessed is discussed. In the second half the specific routes by which FMS systems were introduced are explained and consideration is given to the consequences for the application of accounting criteria of any divergence from the normal sanctioning procedures. The chapter concludes that those who performed the engineering function at the firms in the study enjoyed the opportunity to influence the criteria by which FMS were evaluated

and subsequently monitored. Thus, there was the possibility that accounting criteria would reflect whatever the engineers had defined as the best use of FMS.

5.2 The Normal Capital Sanctioning Route: The Injection of Accounting and Engineering Criteria.

The superordinate position of accountants over engineers which was described in Chapter Two above, was contingent on the separation of ownership from control of a company and the devolution of management responsibility to a number of occupational groups. However, of the 19 firms visited in the course of this study only 15 belonged to large corporate groups where a clear separation of ownership from control had taken place. The remaining four were independent companies. At these firms the owners still played a role in the management of the company, responsibilities had not been devolved to occupational groups to the same extent and the type of opportunity to influence the process of technical change that the accounting and engineering functions enjoyed was different to that described in Chapter Two. Within the group of companies that belonged to corporate groups there were two firms who were distinguishable from the others because of the conscious way in which the engineering function had been promoted. This made easier the introduction of novel systems. In short, the relationship between those who conducted engineering and accounting functions tended to vary between the three different groups. The capital sanctioning process at each of the groups of the companies will be described in turn as a means of highlighting the extent of the opportunities for those responsible for the engineering

function to adapt accounting criteria to reflect the idiosyncracies of particular engineering systems.

(i) The Division of Labour between Engineers and Accountants at the main group of Corporate Firms.

At the main group of companies that belonged to corporate groups, the process of technical change had been instituted into the companies' rules and structures. At a given point each year, production departments would be invited to submit requests for new pieces of equipment. The requests could be for either replacements or additions to existing plant if it was anticipated that demand would rise in the succeeding year. New investments could take place at other times in the year. However, proposals for machinery that required heavy investment were less likely to receive approval if they had not been included amongst the annual investment proposals. All of the FMS systems were reported as forming part of the company's annual investment plan although, as will be reported below, not all of the systems originated from shopfloor management or production engineering.

The amount of funds that were available to purchase new equipment varied enormously between different companies. At the time when the case studies were carried out some companies had insufficient funds to buy new systems for replacement capacity. One respondent reported that purchase of equipment was a "last resort" if current plant could not be "botched up". At other firms sums that would facilitate an increase in the rate of capital invested were available. The case studies were conducted some time after the FMS systems had been justified and the state of liquidity may have

changed by that point. Nonetheless, it might be believed that those with the largest sum of investment funds would find it easiest to justify large investments such as FMS. However, the indications were that this was not the case. The personnel at one company reported that they had never known a year when more than 75% of the annual investment budget had been spent. At another company which often failed to spend all of its investment funds the accountant commented:

"It's alright to have a big budget but we're the ones that are going to have to manage the projects."

This suggests that the application of accounting criteria has an equalizing effect on the sums of capital invested at different firms. The weight of the accountants' influence was greater in this group of firms that belonged to corporate groups than it was in the other two groups of companies. The nature of the capital sanctioning route approximated that which was described in Chapter Two with both engineers and accountants contributing to the process of change but with accountants making their interventions after the engineers. The general course of a proposal for capital expenditure was for it to originate either from the shopfloor manager and then be passed to the production engineer. Alternatively, the production engineer would draw up the proposal himself (1). At this stage the purpose of the machine would be outlined, details of its capacities would be provided and an initial evaluation of the financial consequences of purchasing the system would be made by the techniques outlined in Chapter Four. At some companies the proposal would then be passed to the technical director and subsequently to the local board, the divisional board if there was one, and finally

to the corporate board. Each intermediate level tended to be entrusted with the right to authorise sums of expenditure incrementally greater than the board beneath. Annual capital investment plans were generally composed initially by a production engineer and intermediate boards could make amendments to the plan. However, the final draft had to receive approval from the highest authority in the organisation. The interception of the accountant would come immediately prior to, or at the level of, the local board. The company accountant would be responsible for checking the engineers' reports of the financial costs and benefits of new systems and locating the impact of these in the context of the firm's overall financial performance to enable the board to make the necessary financial decision and prioritise the different investments when necessary.

In many instances the superordinate position of accountants over engineers in the capital sanctioning route appeared to be reenforced by the physical layout of firms. The geography of the factory at Diesel Engine Co. was not untypical of other corporations in the study. At the site visited, which is also the location of the company's head office, the production facilities were situated in a large single storey concrete building. Different stages of the manufacturing process were separated from one another by alleyways. The production engineer's office formed part of a single complex in the middle of the large manufacturing building. Shopfloor management, including the factory superintendent and shop supervisors, also shared this complex. The accountants' offices, on the other hand, were situated in the main office block about 100 yards away. This was separated from the production

departments by buildings accomodating stocks and vehicles. Capital investment proposals would be drawn up by the production engineer and then passed to the accounting office via a number of intermediaries. Accountants would, therefore, receive the proposals some time after the engineer had drawn them up. This physical separation of accountants and production engineers made interaction less likely when queries arose about peculiar capacities of new systems, such as FMS, which were outside of the accountant's normal frame of reference. The accountants would use a computer package with pre-defined parameters to generate figures on the viability of the investment and would make recommendations to the board accordingly.

Accountants' position of greater authority in the capital sanctioning route and its re-enforcement by the distance in time and space between when they and engineers make their respective interventions in the investment decision making process would appear to make it possible for accountants to impose an inappropriate set of accounting categories and calculations on engineering proposals. However, as explained above, it is the contention of this thesis that the engineers' greater knowledge of the mechanics of shopfloor processes and the accountants' failure to gain access to the intricacies of that knowledge militates against such a scenario. Engineers' greater knowledge of shopfloor processes affords them the power to make three important interventions in this part of the process of technical change. The first is to initiate change; the second is to define the contours of that change; and the third is to translate the nature of that change into financial terms for accountants. This provides

engineers with the opportunity to articulate to accountants the nature of the financial benefits of a new system.

The annual capital investment budget provides the trigger for the submission of proposals for capital investment. Engineers are responsible for providing the initial draft of these proposals. The capital sanctioning procedures puts the onus on engineers to be proactive and places accountants in a situation where they are simply reacting to whatever the engineers suggest. Engineers, thus, set the parameters for the subsequent financial decisions. This, in itself, would be insignificant if not for the second factor; that is the separate nature of the engineers knowledge base and the ability which this gives to engineers to define what are and are not feasible engineering solutions to given manufacturing problems.

Engineers in Britain have their own specialist body of knowledge. As was explained in Chapter Two, accountants have not gained access to the engineering intricacy of the shopfloor processes. Thus, any decision which is made after the engineers' intervention is contingent on their earlier formulations and assumes that the earlier decisions were valid. What is assumed to happen at the pre-investment stage is that the production engineer articulates the system that has the technical capacities to facilitate the optimum level of improvement to the performance of a department and the accountant is expected to corroborate that selection. But accountants do not have any means of verifying that the systems proposed is the best that is available. They can only say whether or not the alleged levels of performance can generate sufficient income to earn the levels of returns that the company expects from new investments. One accountant expressed the

dependency of accountants on engineers in the following terms:

"When it comes to us there is one engineering option for evaluation. We highlight areas where the project falls short. Certainly an amount by which it falls short. We may go back and trim it; we may go back and say: "Can you save another person here?" There is a large amount of that done. But, regrettably we've got to rely on others, not to do the accounting for us, but, to give us the simulations on production."

At another point the same person commented:

"I'm not sure it's for the accountants to say: "Well, have you engineered it properly? Could you come up with another way of doing it?" It's an engineering problem. We take the engineering knowledge as given. In fact we always do."

The dependency of accountants on engineers is increased when the company has no prior experience of the proposed equipment as was the case with FMS systems. When the company introduces systems that are similar to those that they are currently using they have the benchmark of past experience when assessing the validity of claims about the magnitude of the parameters of performance. When new systems are introduced accountants are completely dependent on the information that engineers provide.

The engineers, thus, had sufficient influence in the course of the process of technical change to select which system to buy if any system was going to be purchased. However, it is the next factor which determined whether or not new parameters were articulated in the accountants mode of analysis. The engineers utilise one form of discourse; that which describes the operations of technical and mechanical processes. The accountants use another: money. Dialogue between the two different groups, thus, necessitate a process of translation. At all of the firms visited it was

engineers who were responsible for the initial interpretation of the manufacturing capacities of systems into financial values.

The potential number of new manufacturing systems that engineers could propose is extremely large whilst, in the words of one accountant, "the engineering resource is scarce". Any selection that the engineer makes must, therefore, be purposive. That is to say that the proposed system must, at the very least, offer a level of profit that the company finds acceptable. This makes it necessary for engineers to be informed of the financial criteria that must be met, as a precondition to accountants and executives giving any proposal further consideration, in advance of their search for systems. Otherwise, the scarce engineering resource will be wasted on the provision of investment appraisals of machinery that have no likelihood of being accepted. This type of scenario is supportive of King's (1975) arguments who found that only one or two alternative investment options are ever given serious consideration.

Their responsibility for selecting new engineering systems and their general awareness of acceptable financial criteria placed engineers in a position where, as Jones (1990b) describes, they may apply engineering and then accounting criteria alternatively in the course of their own considerations of a potential purchase. In this way they are able to align engineering and financial criteria before presenting the formal translation of the economic merits of engineering systems for consideration by accountants. As Finnie (1986) found, if the engineers, either intentionally or unintentionally, overstate the manufacturing capacities of new systems prior to the final translation and presentation of

proposals taking place, the accountants have no way of detecting the deception at that stage. Deliberate subterfuge did take place at one company in this study, Diesel Engine Co. (See section 5.3 below.) However, Finnie does not give due consideration to the consequences of such subterfuge for both the company and the perpetrator. The financial appraisal is supposed to be purposive; it is expected to provide an indication of whether or not a proposed investment protects a company's level of profitability. The claims made in the pre-investment justification provide the standards by which the systems performance is measured at the cost control stage. If it is found that the promised levels of performance are not realised when the system is operational. the company's profitability may be threatened and questions are likely to be asked of the competence of the person who submitted the proposal. The stage of cost control should, therefore, act as a check against engineers making extravagant claims at the pre-investment stage. See Chapter Seven below for the consequences of the deceit at Diesel Engine Co.

Responsibility for translation does not only provide the scope for engineers to exaggerate the manufacturing capabilities of a system in order to ensure its compliance with accounting criteria, it also allows them to seek a legitimate two-way reconciliation of engineering systems with accounting criteria. That is to say, engineers may reject engineering systems or non-essential qualities of systems because they do not promise acceptable financial returns. At the same time they can identify weaknesses in current accounting practices which do not allow expression of benefits that arise from a new engineering system and when necessary articulate

new categories to express those benefits in financial terms.

There were indications that there were variations in the point at which translation took place between the different companies and this influenced the engineers' ability to articulate successfully changes to accounting criteria. Put simply, the shorter the time period between when translation took place and when the investment was scheduled to be made the greater was the influence that the engineers appeared to have in the choice of system purchased and in the adaption of accounting criteria to reflect that choice.

The most clear example of an increase in the engineers' influence was provided by one innovative accountant at one of the companies in the study. He was experimenting with sensitivity modelling and risk analysis as a means of allowing the financial calculations to be made in advance of the engineers' selection of systems. His hope was that eventually engineers would be able to assess and express the manufacturing merits of a system in financial terms simultaneous to examining their engineering strengths. He said:

"I think what we should do is do, is to take engineering models and apply f notes to them, and drive it the other way around by accountants asking, by saying: "Here are the f notes, tell me how you're going to spend it, tell us what you want to do in engineering terms." You can't do more than that. But in practical terms it can only be done through these simulation models."

There was no timescale for introducing this practice and so it remained just an intention. Nonetheless, it does provide a contrast with two other companies in the study. At the companies alluded to, the engineers held the responsibility for translating manufacturing parameters into financial terms, but they were asked to provide

details of the systems which they expected they would need at least one year in advance. For example, at Boiler Co. a "Long Term Forecast" document was written annually by the production engineer at each of the companies within the group. These documents comprised proposals for new equipment for the ensuing three year period. Each year the local and corporate boards would exclude and include items for further consideration in subsequent years depending on whether the proposals fitted in with the groups overall strategy. It was only in the final year that the suggestions were given full consideration and engineers were expected to provide a financial appraisal. The group accountant, whose offices were situated at the same site as the FMS, had detailed knowledge of the major investments at all of the companies in the group. He described the initial list of items as engineers' "dreams" and he implied that they were simply germinations of ideas that were not commercially viable and would be sifted out as the years passed. The group accountant, thus, received early warning signs of what type of systems were being considered and he could precipitate initial costings of new systems. This initial evaluation could influence the inclusion and exclusion of systems in subsequent years plans in advance of the final economic appraisal being submitted.

The most common scenario was for engineers to be made aware of the general hurdle figure that the proposals had to clear if a system was to be given further consideration. An example of the formal justification sheets which engineers had to fill in is reproduced as exhibit 5.1 (below). The above would tend to confirm the findings of others (King, 1975; Pinches, 1982) that the

Exhibit 1:

Capital Sanction - Cost Justification Summary

DESCRIPTION

Capital Sanction
Reference No.

Location

Project Costs

Year 1 Year 2
£000 £000

Plant
Disposals

Proceeds
£000

A Capital

Installation

.....
.....
.....

B Revenue Charges (ongoing)

Manning

Licensing, Maintenance

Others (specify)

Departmental Manning
With Project
Without Project

Targetted Return
(all projects) 30%

Internal Rate of Return
(this project)

Project Benefits

Year 1 Year 2 Year 3 Annually thereafter
for years.

Realisations of old
equipment:

Manning effect ():

Other gains (specify)

.....
.....
.....

Return on Investment

A Discounted Return @ 30%

Costs
£000

Benefits
£000

Net
£000

DCF Factor
@ 30%

DCF Net
£000

Year 1

2

3

4

5

6

7

8

9

10

1.00
0.77
0.59
0.46
0.35
0.27
0.21
0.16
0.12
0.09

B Internal Rate of Return

.....%

emphasis put on the formal approval stage when explaining the patterns of investment is misplaced.

It is not, however, the intention of this thesis to infer that engineers' responsibility for initiating change, selecting systems and providing the initial justification preempts the exercise of the accountants' authority and the conduct of their responsibilities. For example, if the engineer proposed new parameters of savings the accountants might rule the categories as impermissible. To anticipate the discussion in the ensuing chapters, some accountants expressed reservations about whether inventory savings should be included in the justifications of FMS. They argued that their realisation were contingent on similar improvements being made to the speed at which other departments processed parts. It was thought that this might entail an increased investment in other departments in order to realise the same savings. Similarly, the engineers' submission of a proposal for a system that cleared the desired hurdle figure did not guarantee that the proposal would be accepted automatically. The engineers were aware that executives made decisions on strategic and financial factors other than the hurdle figures that they were given and accountants often contributed to the compilation of the information that was employed in these choices. The accountants were, thus, in a position to recommend rejection on criteria other than one simple hurdle figure. But they could not do so without good reason. The aim of the capital sanctioning procedures was to ensure that the company possessed the plant that allowed them to continue to produce their wares at a cost that protected that company's profitability. Any unreasonable rejection of engineers'

proposals by accountants could act as an obstacle to this.

Engineers were not always happy with their subordinate position in the capital sanctioning route and there were instances where they did seek to overcome this. For example, at Coal Co. the engineer had tried, but failed, to pin down the managing director to a definite DCR hurdle figure at which systems would be accepted automatically. The engineers, therefore, had to accept the accountant's role in analysing financial data and the degree of malleability about such factors as hurdle figures.

In summary, the relationship between accountants and engineers at the main group of companies in this study was described in Chapter Two. Accountants held a formally superordinate position to engineers but were also dependent on the latter for information about shopfloor activities. The practical manifestation of this in the capital sanctioning route was that engineering proposals were evaluated by, and had to gain the acceptance of, accountants. This created the possibility that inappropriate accounting criteria could be imposed on engineering systems. However, engineers' greater knowledge of shopfloor activities and processes casts them in the role of initiators of change. It is they who select what systems possess the engineering capacities to meet the companies' manufacturing objectives. Engineers also translate these engineering capacities into financial terms so that personnel in a company's higher echelons can make the decisions of whether or not to invest. At this stage engineers may exclude some engineering systems for further consideration because they do not meet desired hurdle figures but they also have the opportunity to explain how accounting criteria needs to be adapted to represent accurately the

advantages of a proposed system. It is only after engineers have performed this act of translation that accountants generally intervene. As financial staff do not have the engineering knowledge to propose alternatives they have to trust that engineers have made the best selection in the first instance and give credence to engineers claims of the financial merits of engineering systems. Therefore, the emphasis on the restrictive influences of accountants and accounting criteria may, in some instances, be misplaced. As one manufacturing director in Bessant and Haywood's study explained this is often a legitimation for someone else's inactivity:

"The excuse has too long been made that it is the accountant's fault for not extending investment horizons. This is often used as an excuse not to do anything." (Quoted in Bessant and Haywood, 1985: 45.)

(ii) Some Exceptions amongst Corporate Groups: Two Companies' Promotion of the Engineering Function.

The above discussion has highlighted how, at the majority of companies that belonged to corporate groups, the opportunity existed for engineers to articulate novel accounting parameters when proposing new manufacturing systems. In the course of this study two other companies that had introduced FMS and which belonged to corporate groups were also visited. At these firms the likelihood of accounting criteria being adapted to facilitate the introduction of new systems were increased by the relative promotion of the engineering function. The two companies were Nat Air Co. and Alloy Corp. Alloy Corp. was a British subsidiary of a foreign multinational. The corporation had a special "Technical Division" that was responsible for research into, and development

of, new systems. This division selected specific sites for pioneering the use of a new piece of machinery which might be of use to other divisions within the corporation. The FMS was introduced through this route.

The Technical Division's brief was to develop systems that would be economically viable once operational. They knew in advance the budget which they were working to. Engineers at this division could construct systems with new parameters of manufacturing performance and then explain to the recipient company how these would materialise into financial benefits. Thus, whilst the systems that were introduced were expected to conform to the company's normal payback and DCR criteria the existence of the Technical Division provided legitimation for any new dimensions of performance that were included in the installing company's financial calculations.

At Alloy Corp. it was only specific systems that were introduced through this engineering dominated route. At Nat Air Co., however, all investment plans progressed through a route where engineers had been specifically instructed to express the financial benefits of new dimensions of manufacturing performance.

The attitude of people at Nat Air Co. to the traditional accounting calculations detailed in Chapter Four above was illustrated by a cartoon on an office wall in the department that was responsible for overseeing the investment in, and installation of, new systems. A slogan at the top of the cartoon derided accounting for holding back engineering and manufacturing. Below this was a picture of three beings. The one furthest to the left had "21st Century Engineering" emblazoned on its chest. It also had

a rope going off over its shoulder. The writing on the chest of the middle one read "20th Century Manufacturing". This also had a rope which was tied to its waist and went off behind. The third being which, despite its resistance, was being dragged by the ropes from the other two had tattooed on its chest "19th Century Accounting".

Nat Air Co. had a history of being in the forefront of technological development. The company's financial analysis when justifying new systems was primarily and deliberately focused on quantifying any reductions in work-in-progress that were achieved. This policy had been adopted in the mid-1980s. A director had observed that lying around the factory were large volumes of stocks that had high added value. He commissioned a survey which estimated that the interest costs on the stock was in the region of £2 million per annum. The company responded to these findings in two ways: they set up a new separate department to justify and supervise the installation of all new systems that were required by any production department; and, then, they gave the personnel in the new department a brief to introduce only those systems that reduced work-in-progress costs, even if this resulted in the systems standing idle for part of the time. Although the new department was comprised of engineers, one of the managers reported that they had "poached a couple of chaps from the accounts department" to "beef up" their ability to carry out financial justifications. This provided the department with the capability to express in financial terms the sought after manufacturing capacities. Investments were expected to meet the company's normal DCRs. Nonetheless, engineering criteria had been specified in advance and accounting was expected to follow suit.

In short, Alloy Corp. and Nat Air Co. had promoted the engineering function in different ways and empowered the engineers to include financial expression of novel manufacturing capacities in their investment appraisals.

(iii) Capital Sanctioning Procedures at Small Firms.

It was explained in Chapter Two that the accountants' position of formal superordination over engineers evolved out of the separation of ownership from the control of a company and the devolution of management responsibilities to a number of occupational groups including accountants and engineers.

In the course of this research four small independent companies were visited. The owners of each company were still involved to varying degrees in the management of their respective firms. As a consequence the division of functions had not taken place to the same extent as in the larger corporations, hierarchies of super- and sub-ordinate positions with engineers located below accountants were less evident and accountants, when employed, had less authority to intervene in the capital sanctioning process.

It is of value to discuss in some detail the course of the capital investment proposal of FMS at each of these firms. Their example serve to illustrate the importance of the owners presence, and a company's independence, to the ability of proposers of new machinery to adapt financial criteria to the contours of engineering systems.

At the time when the respective FMS systems were introduced into the four independent firms each company was still owned by its founders. Also, all owners were of an engineering or technical

background and all played some role in the capital sanctioning procedures. In some instances they had intimate knowledge of the shopfloor and, thus, knew the likelihood of a particular investment improving the company's performance. As a consequence accounting, engineering knowledge and consideration of a company's manufacturing strategy were immediately focused on individual investment decisions more or less simultaneously through the medium of particular individuals. This point is best illustrated by the example of Small Machine Tool Co.

The company was owned by a single family. A father and son sat on the board along with other personnel. The father who had established the firm had remained actively involved from its inception and held the position of chairman. He had trained as a production engineer and it was this technical background and the small structure of the company that facilitated his continued, albeit less frequent, involvement in the everyday production management of the firm. The company's production engineer reported that the chairman was "never happier than when he's actually in at the sharp end and looking at ways in which we can manufacture our products better". The only person with detailed accounting knowledge was the company secretary. His role was limited to keeping records of contracts and contributing to the evaluation of proposals which came from shopfloor management. However, these proposals did not take the form of itemised expenditure. Instead, when a new system was being considered a process of negotiation took place between the chairman, his son, the other directors and, at times, the production engineering staff.

In the course of these discussions various scenarios were put

forward by different personnel who used engineering and other types of formalised knowledge along with what might appear to the casual observer as instinctual feelings. Remarks about "gut feelings" and something having the "right feel" or "feeling right" frequently punctuated the discourse of the company's personnel. The chairman was reported to have had a "gut feeling" about the merits of FMS. When the production engineer was asked to describe what he meant by "gut-feeling", he explained it as a rational method of addressing questions, even though, the questions are never asked explicitly, and, the logic employed in their resolution is never fully articulated. He said:

"Most people do interpret a gut feeling as being sort of irrational but I often wonder whether it is rational; whether there is something sub-consciously that you've gone through. Everybody has a different thought process and you've gone through this and you've seen one or two things that you might not associate with the actual problem that you're looking at. For example a customer would probably come round here and he might be looking at a machine. He's talked to the old man (the chairman). He likes the way the old man had been chatting. They've probably got on well together and he likes this company's commitment to product and one or two other things, and he gets this gut feeling that the products going to do him well. He may not feel he has gone through a sub-conscious question and answer routine but he has. So I often feel with a gut feeling there is some rationalisation, it is rational."

What is actually being explained here is that a single individual performs a number of different functions; each with their own system of analysis. These are separated in larger companies into, for example, production engineering, product design, marketing, tender evaluation and cost analysis. As, in this instance, the functions are conducted by one person who either has

the power to override objections to his decision, or is sufficiently attuned to the thinking of the other important personnel to be able to incorporate their objections into his considerations, the full logic of the decisions need not be articulated or recorded in any great detail. This is demonstrated by the installation of the FMS.

The germination of the idea of FMS originated in the mind of the chairman and was gradually developed as his experience of the world in which his company existed unfolded and he persuaded his fellows of the need for them to pursue a particular engineering option. The production engineer described this process in the following way:

"Well the conception was quite remarkable, TC (the chairman), he conceived this many years ago. We're going back probably ten years. But he was fighting a tradition within the company. There are a lot of people who are frightened to commit the company to that sort of expenditure. And he was adamant that he wanted an FMS type principle based on what we call the **Small Machine Tool Co.** five faced machining centre. And he had to fight quite hard with the senior managers, with his son, to actually win them over this way. So there was a lot of sort of convincing he had to do. Although, he's the chairman of the company, he likes to think that at the end of the day it's a collective decision. He was quite concerned quite a few years ago that we had to go this way. He could see the Japanese coming up over the horizon. And it was that which sort of spurred them into redesigning the product range, and the bedtype of machine became of age, and reemphasise the need for us to get smarter for the way that we manufacture our components in-house. And it gave more power to his belief in building an FMS."

The company secretary also explained the key role which the company's chairman played in assessing the financial viability of the system:

"We never did a sort of discounted cashflow sort of thing. TC got it (the FMS) and that's how he thought it was going to run. We did various exercises to see how much we were going to save on it. Because the whole thing has been built up over many many years. He's bought that and said he's going to modify that machine and then he bought that and gone away and modified that. And bought various things. We set down an overall project of what we thought was going to be the final aim of it. We did a cost analysis of it, how it would affect the rest of the factory, and how it would affect the end product. 'Specially on the major castings and TC had an idea on this himself. I mean, give him full due, he knew within a spit of what he was going to save, and he has cut down the overall machine times by, I think, some of them in the region about 100 to about 30 hours, almost by a third. We analysed the whole of the costing and broke it down and then we did the savings, obviously to the DTI to show them that it would be a good project, and, well we never linked the two together. You may say that that is unfortunate because that would have completed the ring but we never did."

It may be that a logical process was not followed and financial considerations did not correspond, totally, with engineering ones. However, the important point is that engineering criteria remained central to the investment decision. These are computed with all other information instead of being subordinated to financial criteria at any earlier stage by the organisation of functions into an hierarchy of offices.

The owner's failure to participate in the day-to-day management of a company and the devolution of responsibilities to separate functional groups does not necessarily lead to engineers' formal subordination to accountants. If the owner continues to play a role in sanctioning the capital investment decision, engineering and financial criteria may receive equal consideration. This is demonstrated by two of the other independent companies visited in

the course of this study.

At the smaller of the two companies, Trans Co., the owner had left control of the firm's everyday functioning to his employees immediately after he had established the firm. However, the firm's small size, recent inception and the structure of its buildings had made it easy for engineering criteria to be put alongside financial calculations. The company had been set up on a greenfield site in the late 1970s. There was a family link between Trans Co. and the larger company discussed here, Industrial Vehicles. Industrial Vehicles. was Trans Co.'s major customer, purchasing 95% of their products at the time of Trans Co.'s introduction of FMS. The whole of Trans Co. was housed in one large building. The production facilities were situated in a large factory and the office block - which was mainly open plan with few physical divides - formed a higher level that overlooked the factory so that production facilities could be seen from the office. The normal practice for capital renewal was for the firm to establish demand for the forthcoming period via telephone conversations with Industrial Vehicles Ltd. and to plan its manufacturing capacity accordingly. This generally involved the owner, the systems manager, production manager, and accountant. In the instance of the FMS they had also invited a supplier of machine tools along to discuss the firm's objectives and it was the suppliers who, after listening to the demands of the company, suggested that FMS provided the most viable option for Trans Co.

Any engineering proposals that were put forward could be rejected if they did not offer a sufficiently high financial return. However, the involvement of engineering personnel at the

outset, along with the suppliers of machine tools in this instance, provided the forum where technical knowledge was analysed in conjunction with accounting information. This meant that engineers shared in the decision whether or not to reject a system and could put forward a range of scenarios, such as suggesting different systems or identifying the areas that had been overlooked if the initial proposal did not clear the investment hurdle figure. Also, the physical organisation of the office allowed discussions to be carried on throughout the justification and pre-installation stages so that problems and financial obstacles were resolved by mutual consent as they arose.

Size and age of company appeared to have little independent impact on the standing of the engineers and their opportunity to influence the investment decisions. **Industrial Vehicles Ltd.** was the oldest and largest firm amongst the independent companies in this study. It had been established in the 1940s and employed approximately 1000 people. Moreover, the original proprietor had retired abroad and his son, who was also the owner of **Trans Co.**, was now the head of the organisation. He had experienced a period of separation from the firm and had not been an omnipresent lynch pin in the functioning of the company. Even if there had not been this patrilineal transfer of control it is debatable whether the original owner's son would have been able to exercise control over all operations given the company's size. Thus, here, more so than at **Trans Co.**, there had been the introduction of some of the practices of the larger firms, including annual budgets and formal capital sanctioning routes. Nonetheless, there remained regular contact between the production engineers, who spent most of their

time on the shopfloor, and the accountant who was situated in the offices. What is more, the limited echelons of higher management and the fact that all investment funds were generated internally meant that it was possible for the accountant and the engineers to discuss the financial and engineering merits of a new system and agree on a proposal for investment in a particular piece of equipment. They could then obtain from the proprietor telephone authorisation for the expenditure in minutes rather than days or weeks. As a consequence, engineering considerations were computed simultaneous to accounting analysis and remained central to the final investment decision.

Collaboration and mutual consensus of different functional groups in the selection of new systems becomes less possible when there is a change to corporate status, as this often entails a relative demotion of the engineering function. The example of the remaining small independent company, **Small Motor Co.**, demonstrates this. At the time of the introduction of their FMS, this firm did not employ any accountants. The company had initially been set up by two people with engineering backgrounds. A member of staff explained that one had provided "the brains" and the other had provided "the backing". It was these individuals who had proposed the introduction of FMS to cater for a new contract for parts from a major customer. The method of computing and analysing information in the decision making process appeared to be akin to that which took place at **Small Machine Tool Co.** Thus, whilst the production engineer reported that a financial appraisal had been carried out it appears most likely that the directors advocating the purchase of FMS would seek to apply accounting criteria to what they

perceived as the contours of the engineering system rather than applying inappropriate financial categories. Another member of the staff described the introduction of the FMS as an "engineering-led exercise" and reported the method of assessing the value of a particular system in the following terms:

"The historical method was that the engineers, and it would normally be John Dennis and Alan Tatlock (the individuals who had established the firm) who did the bulk of the research. They would, in fact, evaluate all the alternatives. We would then convene a meeting of the senior general managers and the thing would be debated and at the conclusion of that debate a decision would then be taken as to whether in the opinion of that forum of managers that investment decision should be given approval."

However, this procedure was to change following the company's takeover by a British-based multinational corporation. An executive board was established and given the responsibility for financial decisions. The only members of the company who had been invited to join the board were John Dennis and Alan Tatlock. The corporation provided a standard form for presentation for all investment appraisals, stipulated the hurdle figures to be observed and, more importantly, put ceilings on the capital sums that could be sanctioned without reference to the entire board of Small Motor Co. and to the corporate board. Also, a company accountant was employed for the first time to oversee the conduct of capital investment justifications and to install a new computerised system of monitoring of production flow. This led to the employment of a whole entourage of financial staff. One long term employee commented:

"You know our accounting department has more or less trebled since they took over. If someone

starts on the shopfloor that's another accountant up here to look after him."

As was explained above, the installation of accounting personnel and an accounting function does not produce accountants' omnipotence in the capital sanctioning route. Engineers are still able to articulate novel advantages of systems. Nonetheless, it does mean a new set of rules were introduced and engineers have to comply with these. Accountants are provided with the means to rule engineering solutions as unacceptable on financial criteria. What is more, in this instance engineers appeared to lose their opportunity to determine the outcome of the final decision making process. Whilst two key individuals with engineering background had been given places on the board of Small Motor Co. and the corporate board they were in a small minority on the latter as engineering had not been a prominent feature of the corporate group's interests prior to their takeover of Small Motor Co. Thus, any proposed investment that exceeded the sum which the local board had the authority to sanction was likely to be evaluated in the final instance by non-engineering personnel.

The examples of the small firms that introduced FMS demonstrate how private ownership of firms by personnel with engineering backgrounds and simplified capital sanctioning routes led to engineering considerations being centralised. Financial criteria were either considered simultaneous to engineering criteria or adapted to articulate the nature of the systems introduced.

Summary.

The separation of ownership from control of a company leads to a division of labour and hierarchy of offices with accountants holding a formally superordinate position to engineers. This separation creates the need for a discourse between these two managerial groups. At firms in Britain accountants have only a limited view of shopfloor operations. As a consequence they are dependent on engineers to provide them with information when the pre-investment evaluation of new systems is carried out. This gives the engineers the opportunity to express in financial terms the novel benefits of new systems such as FMS. At some firms this opportunity has been increased by a company's deliberate promotion of the engineering function. At other companies there has only been a limited movement towards separation of ownership from control and a division of labour amongst management personnel. Consequently, accounting and engineering criteria are easily reconciled when new systems are purchased, evaluated and monitored. Thus, the examples of the firms in this study suggest that the criticisms that imply the imposition of accounting criteria on FMS systems understate the potential of those responsible for the engineering function to influence the composition of financial criteria.

5.3 Production of Justifications and Standards for FMS.

It was acknowledged in Chapter Four that biases in accounting techniques could prejudice companies against certain types of deployment of FMS. However, the preceding section has contended that those responsible for the engineering function have the opportunity to articulate the financial merits of new parameters of performance of novel machinery thus equalizing the impact of accounting techniques on different manufacturing systems. Not all of the FMS systems investigated in the course of this study were introduced through the respective company's normal capital sanctioning route and, as a consequence, their normal accounting criteria was not always applied. The objective of this section is to describe the routes by which the FMS systems were introduced and to explain the implications of any divergence from normal procedures for the application of financial evaluation criteria and the provision of standards for monitoring the subsequent performance of the system.

Of the companies in this study the majority - ie, the 12 companies that had introduced 13 systems including the four small independent companies that introduced five systems - the FMSs were proposed and justified by the normal capital sanctioning route. This left seven companies amongst those that belonged to corporate groups, including Alloy Corp., where the introduction of FMS only took place after there had been some adaptations to the company's normal capital sanctioning procedures.

The nature of these changes may be understood by reference to two criteria: the level at which the idea of FMS emanated - that is whether it was from management, local board or outside of the

immediate company - and, whether a company's normal modus operandi provided the stimulus for the installation. The level influenced whether or not the pre-investment justification was given the emphasis normally afforded to it. The relationship of the proposal to the modus operandi of the company was significant because it provided an indication of the likelihood of a similar route being pursued in the future. The possible permutations of origin and the numbers that fall into each group are summarised in Table 5.1. Each of these changes will be discussed in turn.

Table 5.1 Origins of proposal to purchase FMS at 15 Corporate firms.

Level from which the introduction of FMS initiated	Conditions under which the FMS systems introduced.	(Number)	External	(Number)
Immediate Company	Technical Division:	1	Special Govt. Grant:	1
Directors	Directors appoint member to investigate system installation:	1	Director instructs engineer to revise plans to include FMS:	1
Production Engineering	Project team set up: 2 Production Engineer puts plans through normal route: 8		Production Engineer engages support from other departments on <u>ad hoc</u> bases:	1

At three of the firms where some modification had been made to the capital sanctioning route the initial proposal of FMS originated from the level of production engineering. Thus, accountants' recommendation of support for the investment remained important to the proposal's chances of success. It was reported above that accountants, and the personnel of a company that held a position above them, were able to exercise a degree of discretion in the recommendations and decisions which they made. In the

instances where the appraisal originated from the level of the engineer the modifications to a company's general capital sanctioning procedures may be interpreted as the means by which support from several departments were placed behind the proposal of FMS. This served to add to the legitimacy of the proposal and, in turn, increase the pressure on the accountant to exercise any right of discretion they enjoyed in favour of FMS. For example, at one of the companies, Gear Co., the corporate accountant accepted that the normal payback period would have to be extended to facilitate the introduction of FMS. The nature of the modifications made to the normal processes in these three instances were as follows.

At two of the companies, Gear Co. and Coach Co., the impetus for the modification to the normal capital sanctioning procedures came from the companies' respective needs to increase output. In each instance a project team comprised of representatives from a number of production departments was established. At Gear Co. the owners wanted to shift production of some of their range from their headquarters in North America to their site in Britain. They instructed their subsidiary company to investigate methods for making these parts. The works manager, who was generally responsible for initiating the introduction of new machinery, established the project team. The result was a synthesis of ideas and the development of a shared factory-wide perspective on the advantages of FMS. A collective decision that an FMS would best suit the company's needs then ensued and was presented to the corporate board.

A similar scenario preceded the introduction of FMS at Coach Co. The company planned a new range of vehicles and a project team

was set up to investigate methods of producing these. The idea of FMS was put forward by the production engineer who had encountered it elsewhere. The importance of such a "Project Champion" to the introduction of FMS was implicit at a number of companies in the study and is a phenomenon which has been observed by other researchers in this area (Gerwin and Blumberg, 1981; Bessant and Haywood, 1985). The project team compiled a short list of potential FMS purchases that fell within their budget and invited the suppliers of these systems to give presentations. After this, each department identified their first three preferences of systems. The aggregated scores indicated which system the company should invest in. The normal investment appraisal was conducted and the proposal proceeded through the normal capital sanctioning route.

The proposed increases in output at both Gear Co. and Coach Co. helped to create the conditions for the merger of viewpoints from personnel from different departments. A synthesis of ideas could also take place through the active campaigning of the production engineer. This is demonstrated by the example of Motor Co. Here, the production engineer solicited unofficial reports from other departments. For example, the marketing department was asked to report on the effect on sales of the reduction of cycle times by three weeks. The engineer also sought an accountant's help in preparing an initial appraisal. In this way the accounting categories that would be accepted as legitimate were identified in advance of the formal submission of the proposal and any potential opposition of the accountants was avoided by their incorporation into the preparation of the investment proposal.

In all of the corporations discussed up to now it has been

explained how the potential existed for accounting standards to be adapted to the contours of engineering systems despite the formally superordinate position of accountants over engineers.

In the remaining instances the introduction of FMS was prompted by those above the accountants. This raises a number of important issues. Firstly, were the financial criteria too stringent and applied too rigidly to deter the proposal of FMS by engineers, and was this the reason why FMS emanated from executives or above? Secondly, if accounting analysis had to be jettisoned to facilitate the introduction of FMS, what were the implications for the subsequent legitimacy of the company's prevailing accounting criteria? Thirdly, what was put in the place of the accounting criteria when the decision was made and what were the implications of this for the cost monitoring stage? The remainder of this section will aim to provide answers to these questions whilst outlining the different routes by which FMS were introduced into the companies not yet discussed.

At two of the firms in this study members of the board had initiated the introduction of FMS. In both instances FMS could not be justified if each company's normal accounting criteria had been rigorously applied. There was a divergence between the two companies, however, in the extent to which the directors acted overtly and in a way that could be perceived as remaining within the bounds of legitimate activity allowed by the company's procedures. At Miner Co., there was an open attempt by directors to assess different forms of information simultaneously at board level as a means of identifying the full range of advantages which FMS could bring to the company's performance. The manufacturing

director at Miner Co. explained how this horizontal merger of insights from different analyses was facilitated by the initial decision by the group board - there was no individual company board - to invest in FMS:

"We didn't say to a bunch of engineers: "Go and recommend something and we will accept it or we will knock it down." We looked at it from the point of view of a fairly fundamental piece of strategy. You'll have glimpsed at the back end of the machine shop down there a whole of a clutter of machines looking more like 1930 than 1990. Now that's where we were with the entire shop in 1982. And we said: "Well, what are we going to do? We can just leave it to the normal course of events and the production engineers will come along and say: "Well that machine's worn out now and we need to replace it. The right thing to do is to buy this sort of machine to do it."" We said: "No. That's not the right sort of approach." So we need to have some more specific and some more sort of global input into it. So we identified a project leader if you like or a senior man involved. We said to the technical director of our company, Bob Warren: "You are responsible for developing our new technology."

After the technical director had put together the proposal, he approached the manufacturing director and they then took the facts and figures of the appraisal, which did not meet their normal financial criteria, to the financial director to enlist his support. They then presented the proposal to a full board meeting. This manoeuvre was to ensure that the proposal would be passed by the six-man board despite the poor payback offered by the system. The assent of the full board was obtained and the investment went ahead. The manufacturing director explained the firm's moderation of the accounting criterion in the following way:

"Now it didn't take very long in looking at what we looked for and looked at to say that: "We are going to have to spend upwards of £1 million, ... and if after grants it's a net

bill of between £450 - 500,000 worth of expenditure and we are going to get something like £130 - 140,000 benefit from it we are looking at between a three and four year payback." Now, this is where the act of faith comes in and you're beyond the realms of financial judgement. If we had have only had this thing to consider. I don't think we would have done it, even at that. Because we don't normally go in for paybacks of four years. Now we are looking at one that we know intimately as part of the life blood of our business. So we are saying here that: "This is a poor return. We would normally look for three years or better return on capital. This one looks as if it is worse than that. This one looks as if it is three and a half to four rather than two and a half to three." We had to make a judgement, and we made it intuitively rather than calculated it."

It does not appear unreasonable to suggest that, had the proposal come up through the normal capital sanctioning route, the investment would not have gone ahead. The "global view" of the board, their awareness of exceptional circumstances surrounding the investment, and the strength of half of the board speaking in support of the FMS, made it possible for the investment to go ahead without the normal hurdle figures being realised.

Yet, despite this direct challenge to that validity, the normal accounting criteria were left largely intact. The directors had plotted the levels of performance they anticipated to realise with the system, assessed the value of such performance by their normal accounting criteria, and rendered those as inappropriate measures, but only for the special circumstances which only they were in a position to perceive. The validity of the accounting analysis within the enterprise was, thus, protected even though it had been found wanting (2).

The suggestion for FMS had also come from executive level at

Diesal Engine Co. However, unlike at Miner Co. the director had acted in a clandestine way through the proxy of the production engineer. As a result the FMS was subjected to the normal financial evaluation procedures and accounting criteria. This was to cause a number of problems at the cost monitoring stage. The proposal of the FMS arose at the time of the preparation of the annual capital investment plan. The production engineer submitted his proposals for the plant that he thought would be necessary for the ensuing year. These did not include the introduction of FMS. His suggestions were passed to his immediate superior. The normal practice was for the supervisor to familiarise himself with details and then pass the proposals on to the accountant and the board of directors. However, his supervisor subsequently returned the submissions to the production engineer and told him to incorporate plans for one FMS in his proposals for that year and to suggest the introduction of three systems as part of the long term development of the company.

This directive was reported to have originated from the managing director. The production engineer was not versed in the merits of FMS but he knew that the proposal would have to conform to the company's normal investment criteria. As a consequence he made extravagant claims about the performance of the system along traditional dimensions of machining times and system utilisation. This included proposals for seven-day shift working even though the introduction of such "continental" shifts had not been seriously considered: The accountant reported that seven-day working was never raised with the Trade Unions and had not been introduced. It was only after the plans were redrafted that the proposals were

seen by the other directors. The consequence of this was that no consideration was given to the way in which FMS might bring new advantages. FMS was justified and sanctioned by the company's traditional accounting criteria.

It is not clear in this instance whether the company's FMS systems were viable options. What is clear is that they could not be used for the company's intended objectives and justified by the company's traditional criteria. However, the subterfuge involving the managing director, the production engineer and his supervisor led to the systems being introduced only as a consequence of their capacity being overstated, and this provided the standard of performance to be monitored at the cost control stage. These, of course, were not reached. (See section 7.5 below for discussion of consequence of this point.)

At the final two corporations the drive for FMS originated outside of the immediate company. This contributed to the financial evaluations not being salient in deciding whether the companies invested in FMS. Instead, the pre-investment financial calculation served to define the standards of performance that were to be realised once the systems were operational. It has already been reported that at Alloy Corp., a small number of projects emanated from a separate Technical Division, and this was the route by which the FMS was introduced. As a consequence the company did not have to provide a financial justification for the system prior to its introduction, although they were expected to realise recovery of the investment. Thus, clear expectations of performance were placed on the system once introduced. It is not clear whether a proposal for FMS would have been sanctioned if it had been proposed by the

production engineer as the system may have proved more expensive to purchase from an outside body. However, accounting criteria should not have proved an obstacle in the future: Implicit in the Technical Division's development of the system was the desire for FMS to have a more widespread application within the corporation.

At the remaining company the FMS system would not have been introduced via the normal capital sanctioning route. One director reported that their system would not have paid for itself over 15 years if the company had not received a high level of Government assistance. The impetus for the introduction of FMS at this company, **Brit Machine Tools.**, arose from an open invitation by the then Labour Government. All engineering companies had been asked to submit ideas for installing advanced manufacturing systems. The respondent firm was one of the few to do so and they negotiated a special deal with the Government. The terms of this agreement were that the company would not incur any costs over their existing production methods as a consequence of installing FMS. A grant would be provided as recompense for the additional expenditure. The size of the grant was determined by the company taking a random selection of 50 parts from the range which they produced, calculating the costs of installing a system capable of producing these and the cost of producing the parts with their present system and assessing the difference. This amounted to 70% of the cost of the FMS which the Government provided. The role of the accountant at the pre-investment justification stage was simply to calculate the additional costs of producing with the FMS. However, implicit in these calculations was the standards of performance that was to be realised once the system was installed.

In summary, the pre-investment justification is generally conducted in the course of a company's capital sanctioning procedures. This provides both an indicator of the likely profitability of a new investment and the provision of standards of performance by which the investment may subsequently be monitored. It has been reported that in the four independent companies and eight of the companies that belonged to corporate groups, normal capital sanctioning procedures were pursued when FMS was introduced. Thus, in all bar **Small Machine Tool Co.**, a full pre-investment justification was carried out. In seven of the other firms that belonged to corporate groups, changes were made to the company's normal capital sanctioning procedures to facilitate the introduction of FMS. It has been explained that whilst this sometimes involved modification of accounting criteria, it did not lead to their jettisoning altogether. The extent to which the content of these pre-investment justification appraisals reflected the strengths of the FMS systems that companies introduced and the companies' ability to monitor the realisation of those strengths are the subjects of the next two Chapters.

5.4 Conclusion.

The concern of this thesis is whether inappropriate accounting standards are being imposed on the machine tool configuration of FMS, resulting in the latter's deployment for undesirable ends. This chapter has sought to investigate the potential of engineers to articulate financial parameters that reflect the strengths of the novel engineering systems that they propose, or whether they have to accept the imposition of accounting criteria by others. It

was explained in Chapter Two that, whilst engineers tend to hold a formally subordinate position to accountants at firms where the separation of ownership from control has led to the devolution of management responsibility to occupational groups, accountants are dependent on engineers to provide them with information about shopfloor processes.

This Chapter has reported the details of 19 firms that were successful in introducing a total of 21 FMS systems. It has been explained that at 15 of the firms, where 16 systems have been introduced, there has been a separation of ownership from control. At these companies the engineers' access to information about the organisation of the shopfloor resulted in them having the responsibility for preparing the initial financial evaluation of a system. Engineers did, at least, have the opportunity to articulate novel strengths of new systems when appropriate. The remaining four firms were small independent companies. As a consequence, there had been less pronounced developments in the division of labour between managerial groups and accounting and engineering criteria tended to be afforded parity with one another. This limited the likelihood that inappropriate standards would be imposed on engineering systems. Thus, at all of the companies in this study, the normal capital sanctioning procedure provided the opportunity to those responsible for the engineering function to express the ways in which accounting criteria should be contoured to reflect the strengths and weaknesses of particular engineering systems.

The route by which FMS was introduced at the firms in this study has also been examined. It has been reported that at twelve of the companies, including all four of the independent firms, FMS

was introduced through the normal capital sanctioning procedures. This does not mean that accounting criteria were necessarily altered to reflect the strengths and weaknesses of the respective companies' FMS. This is the topic of the next chapter. What it does mean, however, is that, where the company generally employed accounting criteria they continued to do so. At the remaining seven companies, their respective FMSs were introduced by a different route. In some instances this did involve companies employing other rationales to legitimate the introduction of their systems and either waiving or relaxing the financial criteria used for evaluation purposes. Nonetheless, scenarios of activity were still projected as standards of performance that the FMSs were expected to attain when they were operational.

Footnotes.

(1) Masculine terminology is used in this instance because all engineers in this study were men. No normative inference is intended.

(2) Such a scenario is clearly analogous to Thomas Kuhn's (1970) scientific community's provision of ad hoc explanations that protect the validity of a paradigm even when that paradigm is proved to be inadequate for providing the solutions to their immediate questions.

Chapter Six.

6.1 Introduction.

It is a contention of this thesis that the eventual pattern of deployment of FMS should be seen as the culmination of the process of technical change. Accounting practices are used at two key points in that process: At the pre-investment evaluation stage and, subsequently, at the cost control stage. Chapter Four explained that a large number of critics have argued that there are biases in pre-investment justifications. Whilst these biases might prevent the introduction of FMS they could encourage certain types of deployment that are contrary to a company's best interests. However, Chapter Five has explained that the same engineering staff that are responsible for selecting new systems also prepare the initial financial justification. They are in a position to contour the pre-investment justification to reflect the manufacturing strengths of the FMS. Thus, there is the potential for any variation in the deployment of FMS to be either the outcome of a conscious and deliberate choice expressed in different financial justifications, or the unintended consequence of the application of biased accounting techniques at the pre-investment stage. In order to determine how the pre-investment justification influenced the subsequent pattern of deployment of FMS this chapter will: (i) detail the motivations which led to the introduction of FMS; and, (ii) identify the extent to which each company's personnel were successful in contouring their pre-investment justifications to reflect their stated manufacturing objectives. From this point it will be possible for the next chapter to address the main concern of this thesis: that is the independent impact of cost controls on

the deployment of FMS.

6.2 Companies' Motives for introducing FMS.

It has already been explained that, generally, FMS are most viable when deployed for the machining of a mid-sized range of parts of between 4 - 50 that are required in medium sized batches of between 50 - 2,000 (Avlantis and Parkinson, 1981: 77; Bessant and Haywood, 1985: 33). However, Chapter Three has argued that the benefits of such a manufacturing facility will be particular to a company's situation. That is to say, that they will vary according to the relative strengths and weaknesses of the company's preceding production arrangements and the specific range of parts and batch sizes that the company's markets demanded.

The companies in this study had previously used comparable machining systems. All had employed stand-alone machines for batch production of a range of parts. They did, however, want to realise different types of improvement to their existing performance by introducing FMS. The personnel at the nineteen companies that had introduced a total of twenty-one FMS configurations were asked to explain their motives for purchasing their system or systems. Table 6.1 provides a summary of the responses.

Despite the wide variety of motives that are apparent from the table, there is a clear pattern in the responses given. Whilst the staff of some companies offered only one reason for purchasing FMS, all firms expressed at least one of the three objectives of: "To improve or maximise machine utilisation"; "To reduce costs by carrying less stocks"; or, "To respond to an increasing range of goods". Each of these ends correspond with one or another of the

Table 6.1: Summary of companies' motivations for introducing FMS and the number of systems that were introduced as a consequence of each motive.

Motivation given.	Number
Improve or maximise m/c utilisation:	13
Reduce costs by carrying less stocks:	5
Reduce number of operations:	1
Introduce some unstaffed operation:	2
Bring work back in-house:	3
Respond to diminishing range of goods:	2
Have a demonstration tool:	1
Shift production to Europe:	1
Improve market response by reducing lead times:	3
Improve quality by tighter tolerances:	2
Respond to increasing range of goods:	4

three manufacturing philosophies identified in the earlier chapters of this thesis. The advantages of "Mass Production" are maximisation of output from the resources of labour and machinery. The main benefits of "Just-in-Time" is minimisation of stocks held; whilst proliferation of parts machined is facilitated by "Flexible Manufacturing". This comparability did not appear to be a random coincidence. Conversations with personnel at the firms in the study suggested that the variations in objectives overlaid different perceptions of the economics of manufacturing with FMS.

At the firms where personnel had expressed "Mass Production" aligned objectives, the most advantageous quality of FMS was believed to be its ability to machine each part in rapid succession to one another. This facilitated high levels of machine and labour utilisation and a consequent reduction in unit costs. The accountant at For Machine Tool Co. explained the benefits of FMS, thus:

"I mean the FMS is really built largely on mass production. That's where the big benefits of FMS are; where you've got a large batch size going through. You can set your machine up. You can use that one control and you can put a lot of components through of the same. Now if you're doing one-offs the benefits come a bit limited. You've got the speed and you've got the sort of reliability but you've got to keep changing your workstations and your pallets and your whatever."

This view of FMS was not confined to accountants and did not represent a manifestation of an accounting-engineering divide. Whenever the idea of "If it's not turning, it's not earning." was expressed at a particular firm it appeared to be an opinion that was shared by both engineers and accountants. For instance, at Industrial Vehicles, the production engineer explained his decision to exploit the potential gains of productivity in FMS in preference to adding to the system's cost to acquire flexibility. He said:

"the spindle is obviously the thing that is going to cut the metal and everything that supports the spindle is called flexibility isn't it? And the more you put in there is going to expand the cost That's why it's always easier to justify things on the high volume than it is on the low volume."

By contrast the personnel at companies where FMS had been introduced to realise "Just-in-Time" objectives perceived the economic strengths of FMS arising from its capability to process parts speedily at all stages of the manufacturing process, including the machining and intervening stages. The Production Engineer at Small Machine Tool Co. said:

"The benefits of FMS is the reduction of cutting times and the reduction of lead times."

This capability allowed the company to machine parts when required instead of in anticipation of orders. As a consequence the firm was

able to carry lower inventories.

Elsewhere at the companies where the systems had been introduced for reasons aligned to "Flexible Manufacturing" philosophy the personnel perceived FMS to offer a wide range of financial benefits. This included the capability of switching production to machining different parts without having to invest in a new system. The Production Engineer at Coal Co. explained the full ambit of the benefits of FMS in the following terms:

"When we did the FMS, the project started as a manufacturing idea and then we suddenly realised that we're talking about company profitability. We're talking not just about direct costs, but indirect costs, on total costs, the lead time of getting a part through the factory, being able to change production and being more competitive in a range of different ways is very important."

The clusters of motivations given by companies, and the differing perceptions of the underlying economics of manufacturing with FMS, suggest that it is appropriate to classify the systems in this study by whether they were introduced for reasons that were consistent with "Mass Production", "Just-in-Time" or "Flexible Manufacturing" philosophies. Table 6.2 provides a summary of the number of firms that fall into each category. (1) When it is necessary to provide an overview of the findings of the firms in this study it is this categorization that will be used.

If the process of technical change is a deliberate one, it is to be anticipated that the form of the pre-investment justifications of FMS will vary according to a company's stated motivations for deploying their systems. The extent of any variations at the companies in this study is the subject of the next section.

Table 6.2: Categorization of FMS systems introduced by philosophy that motivation of company coincides with.

	Mass Production	Just in Time	Flexible manufacture
Philosophy 8		1	1
Aligned Motives Only			
Philosophy Aligned & 5 Other Motives		3	3
Totals	13	4	4

nb: This is not intended to infer that the companies concerned were adopting company wide philosophies. It is merely that the advantages which companies sought to realise with FMS corresponded with the advantages associated with the different philosophies.

6.3 Companies' Use of Pre-Investment Justifications.

Chapter Four explained that pre-investment evaluations involve assessing whether the cost of a new system is outweighed by: (i) the extra output that arises from the additional capacity that a new system offers; and (ii) any savings or improvements over existing methods of production that accrues over; (iii) the lifetime of the system. Critics have claimed that each element of this calculation prejudices companies against introducing FMS. It was suggested above that, if the critics' arguments are correct, pre-investment justifications are likely to generate expectations of subsequent performance that lead to any system that is introduced being used for ends aligned to "Mass Production". However, this thesis has argued that engineers and other personnel who propose the introduction of FMS generally have the responsibility for composing the initial pre-investment evaluation. This provides them with the opportunity to contour accounting categories to reflect their perceptions of the manufacturing

strengths of the system that they proposed. It is the objective of this section to investigate: whether the aforementioned bias in pre-investment justifications did constrain companies in their evaluations of FMS; or, whether the engineers were successful in adapting their appraisals to reflect the strengths of their intended systems.

Companies' Definition of Capacity.

Capacity determines the output and, thus, the revenue that arises from the introduction of a system. Chapter Four explained that the pre-investment justification's assumption that the capacity of a system will remain constant throughout its lifetime is alleged to discriminate against FMS. The evaluation calculation recognises the system's high cost, but it does not acknowledge the increases in the value of the system that arises when the company's personnel has accumulated knowledge of the full range of machining options that the system's capacity may be put to (Charlish, 1983).

A suitable definition of the capacity of FMS is necessary before the validity of this argument may be assessed. It was reported above that perceptions of the essential qualities of FMS vary according to a company's manufacturing objectives. Firms that wanted to obtain ends aligned to "Mass Production" philosophy, sought the ability to machine large numbers of parts at speed, in order to realise high levels of system utilisation. Companies that had objectives compatible with "JIT" philosophy wanted the ability to process a batch speedily when they required it. Firms with objectives aligned with "Flexible Manufacturing" philosophy saw FMS offering the capability of machining an increasing range of parts.

The levels of system utilisation, batch size and range of parts that systems were justified against provide a suitable definition of the capacity of FMS with which to evaluate arguments about the biases in pre-investment justifications.

Respondents were asked to report the batch size, range of parts and levels of system utilisation which they used to justify their respective systems. Tables 6.3, 6.4 and 6.5 categorises their replies according to each company's motives for introducing FMS.

Table 6.3 Levels of System Utilisation Desired.

	"Mass Production"	"Just-in- Time" (including hybrid)	"Flexible Manufacturing (including hybrid)
95%+	1		
90 - 94%	6		
85 - 89%	1	2	1
80 - 84%	4		2
75 - 79%	1		1
70 - 74%			
Others		2	

The pattern in the tables shows that the types of expectations of financial performance that are being generated at the pre-

Table 6.4 Batch size of parts intended for system.

	"Mass Production"	"Just-in- Time" (including hybrid)	"Flexible Manufacturing (including hybrid)
1	(1)	4	3
2 - 5			
6 - 10			
11 - 20			
21 - 30			
31 - 40			
41 - 50	6		1
51 - 100	5		
101 - 200	1		
Above	1		

(1) indicates capability not economically applicable to whole of range.

investment justification stage vary between different companies

and tends to reflect accurately, different manufacturing objectives and perceptions of the economic strengths of FMS. That is to say, at the companies where FMS had been introduced to realise "Mass Production" aligned objectives, the systems tended to be justified against high levels of system utilisation and a more limited range of parts machined in larger batch sizes. By contrast, the systems introduced to meet "Flexible Manufacturing" aligned objectives were justified against a lower level of system

Table 6.5 Range of Parts intended for system.

	"Mass Production"	"Just-in- Time" (including hybrid)	"Flexible Manufacturing (including hybrid)
2 - 10		1	
11 - 20	5	1	
21 - 30	4	1	
31 - 40		1	
41 - 50	2		
51 - 75	1		
76 - 100	1		
101 - 200			1
200 +			3

utilisation and the machining of a wider range of parts in smaller batch sizes. At firms where "JIT" aligned objectives had been expressed, FMS was justified against the production of a more limited, albeit higher value, range of parts machined in batch sizes of one, even if this meant a less clear definition of the levels of system utilisation that would be obtained. For example, the Production Engineer at **Small Machine Tool Co.** reported that the focus of the pre-investment considerations was not on levels of system utilisation and that once the system was operational this had ranged from 20% to 90%. The company were happy to accept this as the important objective was to process parts as speedily as possible. Elsewhere at **Scot Co.** the Production Engineer reported

that the system had been justified against 800 units being machined per annum rather than against a level of machine utilisation.

The definition of capacity in the pre-investment justification could, therefore, be varied to reflect a company's manufacturing objectives. The precondition of the system's purchase was that it generated sufficient revenues; not that it had capacity consistent with that of dedicated systems.

It is of value to note at this point that systems introduced to meet "JIT" and "Flexible Manufacturing" aligned objectives were justified against ranges of parts required in batch sizes that fall outside of that which is deemed to be economically viable. (See, Avlantis and Parker, 1981; Bessant and Haywood, 1985.) Although, the availability of grants may have helped to expand the constituency of FMS, it is also likely that Avlantis and Parkinson's formulations are applicable only as a general rule. It will be reported below that FMS systems were justified, in part, by inventory savings and reductions in sub-contracting costs, when introduced to meet the respective objectives of "to reduce costs by carrying less stocks" and "to respond to demand for a wider range of parts". It would appear that where the costs of these are high the constituency where FMS may be employed will be expanded.

To return to the main theme of this discussion, the definition of capacity that each company used to justify their respective systems appears to have been more fluid and less fixed at the time of the pre-investment justification than writers such as Charlish (1983) suggest. It will be recalled from Chapter Five that the engineer or other personnel who conducted the initial pre-investment justification moved between two types of discourse. On

the one hand, they use engineering knowledge to elaborate a production system with the capacity to machine a range of parts in particular sized batches at a given level of system utilisation. On the other, they attribute financial values to that production output to assess whether a profit will be realised. What this involves when a system is not dedicated to a single use is the identification of the permutation of different processes that facilitate the range of production required. The time necessary for changeovers and set-ups, development work, retooling and machining, all have to be quantified and then aggregated into a scenario that the company anticipates will take place. The projections provide the bases for estimating the revenue generated from output for inclusion in the pre-investment calculation. However, that scenario might not materialise exactly as the engineer had originally envisaged when conducting the pre-investment justification. Changes in the the pattern of demand may lead to a contraction of production of one part from the range and an expansion in the production of another. Despite this, the constituent numbers of set-ups, machining, etc., may remain comparable to those that were articulated in the initial scenario. This may or may not entail a retreat from one or another of the dimensions of performance that have been used here to define capacity. Nevertheless, it is the company's personnel who know whether it is range of parts, batch size or system utilisation that is most important to realise the financial returns. They are able to schedule work for the FMS to ensure pursuit of the dimension that promotes the best possible scenario. Thus, what the definition of capacity in the pre-investment justification tends to represent is not a fixed

capacity. It is the parameters of capacity.

Obviously, this is not a total refutation of Charlish's claims. The parameters in the definition are fixed at the time when the pre-investment evaluation is carried out. This is not unrealistic. Any potential proliferation of uses of FMS takes place within a context of the finite machining time offered by a system. This was machining time which had already been purchased to meet some purpose. As the engineers themselves pointed out, proliferation of the potential range of uses might not increase the value of the output when the potential volume was limited by the finite system time, but it would increase the costs of production. The Production Engineer at Miner Co. said:

"There is a limit to how many things you could make at the end of the day, as well, of course. It might be desirable to make 150 different items but it's impossible if you've used your 120 hours per week. You make one thing at the expense of another then. In fact, its even less well because you're only going to be making something now and then, having spent £20,000 on tooling for it, you know. So you will reach a saturation point from a production capacity point of view as well."

Also, companies continued to employ other types of machine tool configuration. As was explained in Chapter Three these are more suited to machining some types of new work depending on the potential scale and regularity of the demand for the new part. This also serves to limit the parameters of potential uses of FMS. The Production Engineer at For Machine Tool Co. spoke in the following terms of the relative merits of putting new work onto FMS and CNC:

"It takes us longer to put a part into manufacture on the FMS in its normal stages than it does on a normal CNC machine. The reason being there are a lot more restraints that we have to abide by. Like, we've got a

tool management package. That means that a man in this department here has got to do all the work necessary to put it into production. He can't leave the supervisor or the operator to do anything. It has got to be rigidly followed from the start to the finish. Now with normal work going through the shop we expect that a supervisor and the operator and the pre-tooling guys all contribute, but they can't with the FMS without ballsing it up."

This raises questions about the division of labour between programmers and operators. These are outside of the competence of this thesis. The important point is that the company's possession of other types of engineering systems places financial limits on the batch sizes of particular parts that may be machined on an FMS and limits the eventual range.

In summary, the capacity of a system determines the number and types of parts that a system may machine and, thus, the sum of revenue that is generated. Pre-investment justifications are allegedly not suitable for evaluating investment in FMS because they assume that the capacity of a system is constant throughout its lifetime and may be defined when the machinery is purchased. It has been argued here that the definition of capacity embodied in pre-investment evaluations are not as fixed as critics suggest. Engineers have been successful in aligning the definition of capacity that they use to justify their systems with their stated manufacturing objectives. In all instances, this has entailed specifying the parameters of the system's use rather than providing an absolute and rigid definition of capacity. This may not be an unrealistic representation as the potential manufacturing options offered by FMS are not as wide as some writers claim. They are limited by actual financial constraints.

Savings Expected from FMS.

The pre-investment justification does not only examine the income generated from the additional output capacity of a system. It also assesses whether the proposed system offers either savings in resources, or other improvements to performance over the existing methods of production. Critics have argued that pre-investment justification techniques focus on the location where the new system will be introduced and generally detail only the reductions in direct labour that are achieved (Primrose and Leonard, 1984b; Shewchuk, 1984). FMS offers a wide range of other advantages including inventory savings (Primrose and Leonard, 1984b; Hutchinson, 1984; Hutchinson and Holland, 1982), ability to vary production (Jones and Scott, 1986), space reductions (Littler and Salaman, 1984), tooling and a host of other gains (Klahorst, 1983) that fail to materialise when other systems are introduced. As FMS systems are expensive and cannot be justified by reductions in direct labour, the failure of pre-investment justification techniques to quantify other gains prejudice companies against installing FMS (Primrose and Leonard, 1984).

To allow the validity of these arguments to be assessed each of the companies in this study were asked to provide details of their investment appraisals. Whilst all respondent firms were prepared to indicate what types of savings they sought to quantify, only some were prepared to divulge details of the actual values of the gains and savings in each category. The responses received are summarized in table 6.6. Reading from the left, the first thirteen systems are those introduced for "Mass Production" aligned objectives, the next four are those that were intended for "JIT"

Table 6-6 Summary of factors built into the financial justification of FMS based on exact figures supplied by the company of the justification or (*) information of alternative expenditure which the company reported they would have incurred had they not invested in FMS.

	Mar. Co.	Coa. Co.	Dual Air	Brit Mach	Tran Co.	Smal Moto	For Mach	Moto Co.	Ind. Veh1	Ind Veh2	Gear Co.	Boil Co.	Dies Engl	Mine Co.	Scot Co.	Smal Mach	Prin Co.	Nat Air	Allo Corp	Dies Eng2	Coal Co.
		*																			
Grants	11%	12.5%	30%	70%	22%	33%	33%	No	No	No	46%	33%	33%	46%	60%	33%	10%	33%	33%	26%	26%
Labour#	4%	3%	20%	Yes	2%	3.5%	6%	6.25%	Yes		10%	17.5%	.5%		3%		Yes	Yes			18%~
M/nery	8%	60%+			Yes	Yes		44%	Yes								Yes			25%	
M/c tim				Yes		Yes						Yes		8% pa							
Set-ups				Yes	3% pa																
Tooling							1% pa														
O'head	17% pa																				3%
B'dings								20%													
Sub-con					Yes					Yes			20% pa		Yes		Yes	Yes	Yes	15% pa	
Output					6% pa		5% pa		Yes	Yes			Yes				Yes	Yes	Yes	Yes	Yes
WIP	2.5%			Yes			1.2% pa	7.5%			7%	Yes		14.5%	13%	Yes	Yes	Yes			3%
Int'est								1.12% pa						3% pa	1.5% pa		Yes				
Ind Lab														3% pa							
Energy								1% pa									Yes				
Service								.5% pa													3%
Scrap							3.5% pa											Yes		Yes	
Intan's																					8%

Notes # Labour figures = pa. except at Coal Co.
 ~ Figure includes labour but is wider category of direct costs.

types of objectives, and the last four are those that were purchased to meet "Flexible Manufacturing" aligned ends.

The table shows that there are a wide range of savings and advantages included in the pre-investment justifications of different systems. However, there is a pattern to the responses. This suggests that the engineers are enjoying some success in expressing the benefits and advantages that might be expected to arise from their respective firm's particular deployment of FMS. It was reported above that different companies perceived the essential qualities of FMS in different ways and sought different types of improvements to their manufacturing performance when introducing FMS. The improvements sought were: greater exploitation of machine and labour productivity; more effective use of materials used; and, a proliferation of the range of parts that may be produced on the same system.

The table shows that at firms where systems were proposed for "Mass Production" aligned objectives, expectations of improved machining times and/ or reductions in labour were expressed in the financial justifications. For example high levels of labour reductions were expected to accrue annually at Dual Air, Boiler Co., Gear Co., Motor Co., For Machine Tool Co. and at Industrial Vehicles Ltd., although exact figures were not provided at the latter firm. It can also be seen from the table that other productivity related savings such as reduced machining times and reductions in set-ups also figured prominently in the financial justifications of this group of companies.

At the firms where FMS was introduced to realise the "JIT" aligned objective of reducing the inventory carried, savings in

work-in-progress featured prominently in financial justifications. The table shows that the savings at Soot Co. and Miner Co. were 13% and 14.5% respectively. My own calculations based on the information provided by Small Machine Tool Co. and Print Co. suggest that inventory reductions accounted for somewhere between 20 - 33% of the cost of ^{the} Systems.

There was one group of companies - ie, the firms that had introduced their systems for the "Flexible Manufacturing" aligned objective of "responding to demand for an increased range of goods" - where FMS tended to be evaluated without a category of financial advantages that corresponded with the companies' stated objectives for introducing their respective systems.

An obvious explanation of why companies tended not to express the merits of flexibility in their financial appraisal is the nature of their preceding production arrangements. All of the companies had previously used standalone systems. These are suited to the economic production of a wide range of parts in small batches. Thus, the companies were not actually gaining the capacity to manufacture flexibly when purchasing FMS. Their expression of motives of "responding to demand for an increasing range of goods" would therefore appear to be a mixture of factors including pro-FMS rhetoric, a relative absence of stable markets and an increase in the range of parts machined in-house due to the added capacity of FMS: Three of the companies used their introduction of FMS to bring back in-house work that had previously been sub-contracted out. Thus, reductions in sub-contracting costs figured prominently in their pre-investment evaluations.

There was one company, amongst the group that had introduced

their system for "Flexible Manufacturing" purposes, where there had been a conscious attempt to articulate, in their pre-investment justification, a new category of financial advantages that was intended to represent the flexibility of their system. At Coal Co., the engineer had included a category of "intangibles". Although this included financial values attributed to factors such as a percentage of a last order and improved company image, the company had no clear formulae for determining these. Instead the sums were the subject of a process of negotiation by, and with, a number of directors. In reply to a question of whether there had been any objections to the "intangibles" being included in the appraisal the Production Engineer said:

"Well, obviously there were people who didn't agree. At the end of the day it was our manufacturing executive, chief executive and marketing director who agreed on these figures, and so any other member, he sort have had to really argue. There was no strong enough argument against it, because it's really a matter of if someone said it was £10,000, somebody else might have said it was £50,000. We may have struck a point in the middle. But we had about eight items [These included such factors as company image and the ability to respond to changes in demand] and that totalled to about £200,000. That was the intangible benefits."

When asked about accountants' willingness to accept such advantages as legitimate, the Production Engineer claimed that the engineering department had seized the initiative by selecting FMS. Worrying about the means of justifying the system was a subsidiary issue. He said:

"The time we did the FMS 1 we realised our present manufacturing was completely out of date, we just could not cope in terms of investment appraisal to our present system, and really it's a chicken and egg. We wanted to go

ahead with the investment and if we waited for accountants to get their house in order and to agree on a system for costing we would never have got the projects off the ground."

Whilst systems installed for "Flexible Manufacturing" aligned objectives were introduced to machine a wider range of parts than other systems in this study, no additional gain of flexibility over the companies' preceding production arrangements had been achieved. Thus, no company had any systematic way of expressing such an advantage.

The table also shows a large number of savings which appear particular to different companies. Some of these almost certainly do reflect the idiosyncracies of different companies' situations. For example, at **Motor Co.** the company would have had to rebuild the roof to a building to accommodate the alternative replacement systems that required a much larger physical space than FMS. However, other advantages such as service, scrap and tooling which appear in only a small number of pre-investment justifications may have been more generally accessible. The criticisms made of the focus of pre-investment justifications may, therefore, have some validity. However, the appearance of such savings in some financial justifications indicate that this is not a weakness intrinsic to the evaluation. It is a consequence of how they are employed.

It is interesting to note that where such savings were included in the pre-investment evaluation of systems it was at those corporate firms, for example, **For Machine Tool Co.**, **Motor Co.** and **Coal Co.** where the pre-investment evaluation had been composed by engineers. This tends to confirm the arguments made in the preceding chapter: engineers do have the opportunity to articulate

new gains when proposing FMS. There may be a number of reasons why other engineers did not include additional savings in the pre-investment justifications. The availability of grants, see pp 212 - 3, and the relaxation of other criteria used in the same calculation, such as the length of time allowed for amortisation, may have made this unnecessary.

There was also some evidence to suggest that engineers' past experience of accountants' unwillingness to accept certain categories of savings may have discouraged engineers from attempting to quantify some gains. The group accountant at Boiler Co. reported that he was generally unwilling to include any savings that could not be monitored by the company's existing financial apparatus. However, there was only limited evidence to suggest that accountants were actually ruling that certain categories of savings were not legitimate after engineers had proposed their inclusion. It was only in the instance of Dual Air Co. where there was a clear disparity between the accountant's and engineer's view of what benefits of FMS were legitimate. The engineer reported that he had included inventory savings in his financial justification of FMS. The accountant reported that stock reductions did not figure in his calculations and the general rule was not to allow such savings. But this firm was the exception. Engineers did not generally propose savings other than those in the table. This suggests that, whilst engineers may not include certain types of benefits of FMS because they anticipate that they will be ruled as illegitimate by accountants, in other cases any failure to provide a financial justification that mirrors the strengths of a manufacturing system may be a consequence of engineers' lack of understanding of

accounting techniques.

The final factor to note from the table of advantages that were categorised in the pre-investment justification is the presence of grants. Grants fall into two types: those that discriminated in favour of a company's introduction of FMS; and those that did not. The former are awarded only to those companies that introduce FMS. These include grants allocated under the FMS scheme and Brit Machine Tool Co.'s special award under the MAPCON scheme. The latter sets of grants offers recompense along some other criteria for the investments made by companies and are allocated when any capital investment meets the relevant criteria. These include Regional Development Grant (RDG)s and European Development Fund (EDF) awards. All but four of the systems in this study were introduced with the assistance of grants that prejudiced companies towards FMS. The exceptions were the systems that were introduced at Trans Co., Motor Co. and the two FMS systems installed at Industrial Vehicles Ltd. While Trans Co., Miner Co., Gear Co. and Scot Co. received RDG grants, Scot Co. also received an EDF award.

The importance of grants to investments in FMS may be interpreted in various ways. First, as some authors have argued, systems would not have been introduced without the Government's provision of financial assistance (Jones and Scott, 1985). Given the scale of awards, it would not be tenable to argue that grants were not essential to some investments taking place. For example, at Brit Machine Tool Co. one director reported that their investment in FMS would not have been recovered within 15 years without the 70% grant that the company had received. However, a

question of more salience to this discussion is, whether there were instances where FMS constituted a viable investment without grants but would not have appeared as such because the pre-investment justification failed to represent accurately the advantages of the system. No straightforward answer can be given to this question. A number of production engineers did report that they believed their boards of directors interpreted the receipt of grants as, the Government providing a vote of confidence in the FMS system that the firm intended to purchase; and this was of equal significance as the cash itself. This is, perhaps, indicative of financial evaluation techniques leading boards of directors to have a conservative approach towards investment.

It is also of note that four of the systems introduced for "Mass Production" aligned objectives - three of which were at independent companies - were installed without the assistance of FMS grants. Given the easier merger of engineering and accounting ideas at small independent firms, the less complex systems required for such purposes, and the aforementioned ability of pre-investment justifications to report advantages associated with "Mass Production" aligned objectives, it is possible to suggest a tentative conclusion. That is, it might be that grants have helped to overcome biases in pre-investment justifications at the corporate firms where systems have been introduced for motives aligned to philosophies other than "Mass Production". However, it is also possible that in other instances, FMS was a viable investment because of the provision of grants when it otherwise would not have been, regardless of the success of the company in deploying the system to realise its optimal performance.

In summary, critics have argued that the myopic focus of pre-investment justifications leads companies to seek to justify the introduction of new machinery against the savings that accrue at the location of the new installation. This prejudices companies against the introduction of FMS. It has been argued throughout this thesis that as the personnel responsible for proposing new systems also prepare the initial financial justification, they have the opportunity to contour the pre-investment appraisals to the parameters of FMS. However, the existence of gains are context bound and limited by the strengths of a company's preceding production arrangements and their manufacturing objectives when deploying FMS. It has been reported in this section that the initiators of change have been relatively successful in expressing the major financial benefits that were likely to arise from their stated manufacturing objectives. Thus, where FMS has been introduced for "Mass Production" aligned objectives improved machining times and reductions in labour featured prominently in the financial justifications of systems. Similarly, inventory gains were evident in the financial appraisals of systems introduced to attain reductions in stock. The failure of firms that reported their objective as "to respond to markets for an increasing range of parts", to express such a desire in the financial justification might be attributed to their prior employment of conventional batch production systems. This meant that the attainment of flexibility was not a new quality.

It has also been reported that there were a number of minor savings that might have appeared in pre-investment justifications but were not expressed. There appears to have been a number of

reasons for this including engineers failure to identify the gains when conducting the initial financial appraisal. However, in the majority of firms in this study any failure to do so was offset by their receipt of grants.

Useful life of systems.

The two preceding factors determine the income that a system will generate at any particular point. It is this sum, multiplied by the useful life of the system, that determines the total income that a company will receive from their investment. It is total income which is used to evaluate the potential for any investment to increase the company's profitability. Pre-investment justification appraisals have been criticised for understating the potential advantages of investment of FMS by misrepresenting the useful life of the system. (See Primrose and Leonard, 1984a.) The reader may recall from Chapter Four that there are two criticisms made of the notion of lifespan in pre-investment justifications. First, the financial evaluation assumes that the system's useful life commences immediately following its installation. As a consequence returns are expected from that point even though FMS is comprised of a number of constituent elements that have to be aligned with one another. Second, pre-investment evaluations only recognise the returns that are generated in the first two to three years after a system has been installed. Each of these alleged weaknesses in pre-investment justifications will be examined in turn.

Initial Period

The type of contract that companies used to purchase FMS fell into two broad categories. Turnkey packages and non-turnkey packages. When systems were purchased as turnkey packages a company contracted with a supplier who was responsible for installing the whole system. Non-turnkey packages were purchased piecemeal often from different suppliers and the company took responsibility for operationalising the system. When a system was purchased as a turnkey package the vendor sold their customers the promise of a system complete with levels of performance if the system was deployed for the purposes for which it was purchased. In these instances payments for systems, and potential financial penalties on the vendor, were related to the actual performance of the system (2). Therefore, any failure to express a gestation period in pre-investment justifications should not have constituted a problem. Effectively, purchase of the system was not completed until it had reached the levels of performance in its financial appraisal. Eleven, or just over half, of the systems in this study were purchased as turnkey packages.

The need to represent a period for debugging in the pre-investment justifications of the remaining systems did not prove an obstacle to other companies introduction of FMS. Extra time was allowed before recovery of the investment was expected to commence when eight of the remaining ten systems were justified. Of the two companies not already accounted for, one was the firm that had not used any financial justification. It was not established whether the remaining company allowed extra time for debugging when conducting their initial appraisal.

Thus, the need to represent a gestation period for debugging of FMS when the financial justification was carried out did not prove an impediment to the installation of systems at the companies in this study. Firms either purchased systems on contracts where they did not make payments until desired levels of performance were attained, or they adapted their appraisal techniques so that the period of recovery² of the investment was deferred.

Useful life attributed to FMS.

The use of appraisal techniques, such as payback, that expect recovery of an investment over a short period, may discourage investment in expensive manufacturing systems such as FMS (Primrose, Bailey and Leonard, 1984). However, FMS are not the only expensive systems. Therefore, it is likely that companies would have been confronted by this weakness in the past and adapted their pre-investment justification accordingly, prior to their installation of FMS.

All of the respondent firms were asked which techniques of appraisal they generally used to evaluate new systems and any changes that they had to make to their normal methods in order to be able to justify FMS. Table 6.7 categorises the responses (3) according to the company's general motive for introducing FMS.

The table shows that there were clear variations in both the techniques and the amortisation period used by companies to assess the merits of an investment prior to, and at the time of, the proposal of FMS. Nevertheless, it is possible to make a number of general points about the pattern of responses. Firstly, regardless of whether payback calculated over two years is a prohibitive

technique per se, when used to evaluate FMS its effect appears to be limited in practice. The majority of firms in this study were using other evaluation techniques before they decided to invest in FMS. Only six companies, that were responsible for introducing a total of seven systems, were using payback calculated over periods of less than three years when evaluating large investments immediately prior to their purchase of FMS.

Table 6.7: Method of appraisal used by companies to appraise the value of new systems and changes made for FMS.

	"Mass Production" Aligned Objectives. Normal FMS		"Just-in-Time" Aligned Objectives. Normal FMS		"Flexible Manufacturing" Aligned Objectives. Normal FMS	
Payback:						
Under 3 years.	5	2	1	-	1	1
3 - 5 years.	3	6	-	1	1	1
Contract length.	3	2	-	-	-	-
DCF:						
7 - 9 years:	-	-	1	1	-	-
10 years & above.	2	2*	1	1	2	2
Criteria not articulated.	-	-	1	1	-	-
Criteria waived for FMS.		1		-		-

* DCR figure reduced.

Secondly, the majority of companies, ie, four out of six, that had to change their evaluation techniques generally used payback calculated over two years. The success of two other companies that were responsible for introducing three FMS systems indicates that local factors can ameliorate the debilitating effect of payback calculations. Nevertheless, the general pattern of change in techniques suggest that these methods are prohibitive.

In summary, whilst payback calculated over less than three years may generally be a prohibitive method of appraisal, it was

not problematic at the firms in the study because: (a) the majority of firms did not generally use this technique prior to their installation of FMS; (b) some firms modified their use of payback when evaluating FMS; and (c) where firms did persist with payback, local circumstances served to militate against the restrictive impact of amortising capital over periods of less than three years.

Summary

The overall picture presented by this section is that the biases in pre-investment justifications are not intrinsic to the practices themselves. The definition of capacity of a system, the quantification of benefits, and the notion of lifetime that companies employ when conducting their pre-investment evaluation of FMS are all being modified. These modifications have facilitated the introduction of FMS at the firms in this study. The evidence suggests that the modifications that are being made are purposive and reflective of the gains that can be anticipated from the particular contexts of the different companies preceding production systems and respective intentions when introducing FMS. It is possible that further modifications could be made. However, it appears from the available evidence that the initiators of change must take some responsibility for any failings. It does not appear to be that accountants are simply ruling that attempts to adapt pre-investment justifications are illegitimate.

6.4: Conclusion.

The argument of this thesis is that the eventual pattern of deployment of the new machine tool configuration of FMS can only be

understood as the culmination of a series of stages. These stages encompass the whole process of technical change. This chapter has examined the role of accounting practices in the early stages of that process. It has been reported that companies generally selected their system to meet one of three types of objectives. These motivations reflected different perceptions of the economic strengths of FMS and conformed with one or other of the manufacturing philosophies of "Mass Production", "JIT" or "Flexible Manufacturing". They are also manifest in the different range and batch sizes of parts that the systems were expected to machine. Contrary to what a number of critics have argued there is evidence that pre-investment justifications are being contoured to express companies' aspirations for introducing their systems. These should provide the standards by which FMS are monitored at the cost control stage. Whether this was the case is the topic of the next chapter.

Notes

(1) The motivations expressed by personnel at two of the companies were in some ways hybrids of two philosophies. Miner Co. wanted to reduce the amount of stocks carried. They also selected FMS because the local trade unions had resisted successfully the introduction of three-shift working. FMS offered the possibility of operating through part of the night with a skeleton staff when, hitherto, the factory had been closed. In this sense it allowed the company to increase the productivity of their machinery. Thus, their motivations were a hybrid of both "Mass Production" and "Just-in-Time" philosophies. The other company that had introduced FMS for reasons that were compatible with more than one philosophy was Nat Air Co. It will be recalled from Chapter Five that Nat Air Co. generally selected systems that facilitated reducing WIP. Whilst FMS was expected to satisfy this end it was purchased because the company wanted to machine an increasing range of goods. The companies' objectives were, therefore, compatible with both "Flexible Manufacturing" and "Just-in-Time" philosophies. However, the main motivation of Miner Co. was to reduce stocks and the primary motivation of Nat Air Co. for selecting FMS rather than some other system was to respond to demand for an increasing range

of parts. For the purpose of simplifying the analysis and discussion, when it is necessary to categorise these different systems they will be classed according to the firms primary motivations. It should also be stated that Diesel Engines. had a clear strategy of linking the type of their FMS system to the particular batch sizes and ranges of parts. The second system did in fact fall between the first system introduced for productivity reasons and the third system which is not included in this study which was intended for flexibility purposes. The second system is included in the flexibility group both for reasons of simplicity and because its inclusion in this group leads to a fairer representation of the motivations and systems at the companies in this study.

(2) Interviews with purchasing companies and with a supplier of FMS.

(3) At a number of companies where payback was used the accountants reported that other methods such as DCF or ROI were used to corroborate payback findings. However, as successful payback tended to be a pre-requisite for subsequent calculations the firms are categorised as using payback. The firms where this was the case were Dual Air Co., Motor Co., Alloy Corp. and Diesel Engine Co. The generation of extra information also had the added function of serving to legitimate the accountants' position and buffer directors from requests for all types of equipment that might be viable but which the company might not want to invest in for non-commercial reasons.

Chapter Seven.

7.1 Introduction.

It is now possible to address directly the claims that the application of post-installation cost control is resulting in FMS systems being deployed for purposes that are detrimental to the user companies. It will be recalled from Chapters One and Four of this thesis that other writers (Jaikumar, 1984; 1986; Skinner, 1986; Jones, 1989) have explained the pattern of deployment of FMS systems for the manufacture of a small range of goods, in large batches, by reference to the biases in cost control. Cost monitoring, allegedly, emphasises maximisation of system utilisation and volume of output and this discourages companies from using FMS for the more profitable purpose of manufacturing a wide range of parts in small batches.

The notion of a single best use of FMS has been challenged in Chapter Three. It was argued that it was more appropriate to establish the best use of a system by reference to a firm's own manufacturing intentions, if that company is deploying FMS to machine a range of parts in batch sizes not suited to economic manufacture on the alternative systems that are available. The preceding chapter has found that there was not one definition of the best use of FMS shared by all firms. Instead there were three. These were: machining of a wide range of different items in small batches to reap the benefits of being able to manufacture new parts without purchasing new machinery, or "Flexible Manufacturing" aligned objectives; only machining parts when demanded by the market in order to realise reductions in the cost in inventories carried, or "Just-in-Time" aligned objectives; and, the machining

of a limited range of goods in large batches as a means of reducing unit costs by increasing the levels of utilisation of machinery, or "Mass Production" aligned objectives. These different aspirations were manifest in different range and batch sizes of parts that companies hoped to put onto their respective FMS systems. The engineers, who were responsible for identifying the company's manufacturing objectives when deploying systems, also composed the pre-investment justifications and, enjoyed some success in expressing the financial advantages that were likely to arise from their respective firm's particular deployment of FMS. It is to be expected that the claims in the pre-investment justification should then provide the standards of performance by which the system is monitored.

The objective of this chapter is to examine the actual mechanisms of cost monitoring and its success, or otherwise, in allowing a company to realise its initial manufacturing objectives when introducing FMS. In the course of this investigation the validity of other writers' criticisms of cost control will be examined. It will be recalled from Chapter Four that the rewarding of workers for high output, and the pursuit of high quotients of output per unit of labour or machinery expended, allegedly result in flexible systems being deployed for the large batch production of a limited range of goods. Thus, the first section in this chapter will report briefly the extent of the presence of performance related payment systems at the companies in this study. The second section will detail the strengths and weaknesses of flexible budgets, the main technique used for cost monitoring at the firms in this study, and investigate whether they encourage

pursuit of productivity as suggested by critics of cost control. The third section will investigate the impact of cost control on the actual deployment of FMS. It will compare each company's desired levels of performance from systems introduced for different purposes with that which they actually attain. This part of the discussion will conclude that, regardless of the weaknesses that are evident in flexible budgets, cost monitoring promotes realisation of each company's initial manufacturing objectives by transforming the definition of capacity embodied in the pre-investment justification into the definitions of standards of performance to be monitored at the post-installation stage. Thus, cost control can actually promote the realisation of flexible objectives when companies had initially sought realisation of these ends. The final section of this chapter will investigate the separate cost monitoring practice of audits. It will report that, contrary to the findings of other writers, audits have been conducted on a number of FMS systems. However, they have little independent effect because their main purpose is to amplify the findings of ongoing cost monitoring.

7.2 Monitoring and Motivation of Shopfloor Workers.

It was reported in Chapter Four that Wheatley (1989) notes that employers use payment-by-results schemes to ensure that workers pursue the maximum volume of output. Wheatley contends that this form of payment system leads production operators to oppose the employment of work techniques that could reduce the volume of output and, thus, the levels of their bonuses.

There was no evidence to support these claims at the firms in

this study. Most companies used measured daywork payments prior to their installation of FMS. As workers are paid for the conduct of their stipulated work, and not for the volumes of output that they produce, measured daywork should not be incompatible with any deployment of FMS. There were three firms where some form of bonus system had operated prior to the introduction of the FMS. When the respective systems were introduced one company negotiated with their FMS operatives to switch to measured daywork. The other two weighted their bonus systems to reflect the potential changes to output that were likely to arise. It would, therefore, appear fair to suggest that payment systems do not constitute an obstacle to the installation of FMS.

7.3 Continuity between Pre-investment Justifications and Ongoing Cost Control and the use of flexible budgets.

Chapter Four explained that the critique of cost control offered by a number of writers is that: the definition of output in terms of numbers produced (Jaikumar, 1984: 26; Jones and Scott, 1986: 7; Jones, 1989: 49), coupled with the impetus to maximise the output from the inputs of either labour or machinery (Jaikumar, 1984: 23; 1986: 71), results in FMS being used to machine a limited number of parts in large batch sizes when this is not appropriate.

The findings of this research do not contradict the description that these critics have given of the apparatus used for cost monitoring. For example, 19 of the 21 systems studied were measured by how well they performed over each hour the system was machining. The remaining two companies evaluated the performance of their system vis-a-vis the labour hours expended in its operation.

It will also be made clear in the ensuing discussion that the volumes of parts machined were monitored, and the merits of the performance of a system were assessed, through a comparison of the output of a system with the resources expended in their manufacture. However, a distinction must be made between the apparatus used for monitoring the standards of performance of FMS and the actual standards sought. It has been argued throughout this thesis that when engineers prepare the initial financial justifications of FMS they stipulate the performance profile of the system and this provides the standards by which the system is then monitored. The objective of this section is to describe how these standards are constructed into the cost monitoring apparatus when new systems are introduced, so that a manufacturing system may be deployed for the purposes for which it was purchased.

It will be recalled from Chapter Five that each year production engineers were invited to submit proposals for new systems. These systems were supposed to provide the capacity to machine the volumes and range of parts that were demanded by a company's markets, but which would not be manufactured by a company's existing facilities in the forthcoming year. A financial appraisal of the proposed system would be conducted. This would assess whether the revenues, generated by the improvements that the system brought to a company's ongoing manufacturing performance, outweighed the cost of purchase. If they did the purchase went ahead. The selection of a new system, thus, involves two different types of statement that aim to explain the same scenario. Firstly, there is the description of an engineering system that is suitable for the machining of certain types of parts in particular batch

sizes, which is able to fill a manufacturing void at the company. Secondly, there is a statement of the levels at which different resources are to be consumed when the system is machining the desired parts if the company's profitability is to be protected.

It is the engineers who are primarily responsible for ensuring that the system is used, subsequently, to machine the types of work for which it was purchased. It is accountants who are responsible for monitoring whether resources are consumed at the desired levels of efficiency. A third group of personnel, production management, hold the responsibility for ensuring that the work allocated to the FMS is processed at the desired levels of efficiency. A description of each of these groups' responsibilities will serve to demonstrate how the three different manufacturing objectives (1) sought by different respondent firms were realised when FMS systems were introduced.

After a system has been purchased and operationalised to the expected standards of performance by the engineers, and suppliers where systems were purchased as turnkey packages, it was generally placed under the direct supervision of a production department. However, it also added to the total capacity of the machining facilities that engineers had at their disposal. It will be recalled from Chapter Three that the different types of engineering systems that companies possess are, more or less, suited to the economic manufacture of parts that are required in different ranges and batch sizes. The company's engineering staff had to reconcile the demand for a company's products, with the manufacturing facilities' capabilities to meet that demand, in the most economic way. Thus, the engineers, with the assistance of schedulers and

shopfloor management, allocated work to departments and manufacturing systems according to their available capacity when machining operations had to be performed.

If customer demand was as had been projected in the pre-investment evaluation, parts that the system had been introduced to machine would be channelled to the FMS. If the pattern of demand changed and the FMS had to be turned to a new use, the system was still expected to attain the levels of performance stipulated in the pre-investment justification.

It is important to remember that it was the engineers who had been responsible for the preparation of the initial financial justification of FMS. They knew the standards of performance that the system was expected to attain along the different dimensions of utilisation, batch size and range of parts. They also recognised the argument made in Chapter One above. That is, there is a trade-off between realising these different ends. The engineers were aware of which dimensions of the system's performance promised the greatest financial reward (see Section 6.2 above) and they allocated work in ways that ensured protection of the dimension essential to earning the most profitable return. For example, at Small Machine Tool Co. where the system had been introduced for reasons aligned to "JIT" philosophy the production engineer reported:

"We have situations where the FMS is not required. We find it more important that when the castings come in, we bring them in in a just-in-time policy. We bring them in, they're machined, they're to the fitter, he assembles them and they're out of the door and we try and get the cash as quickly as possible. We're not

too concerned if we walk through there and parts of the FMS are'nt running. We are more concerned in getting the component in as late as possible, through the FMS to the fitter in time for him to assemble them. That is far more important than worrying about we only got 20% utilisation. As long as obviously the utilisation is only 20% because that's all we required."

Similar comments were made by engineers elsewhere. For example, at Coal Co. where FMS had been introduced for reasons aligned to "Flexible Manufacturing" philosophy, the Production Engineer commented on his willingness to sacrifice levels of system utilisation to obtain a wide range of parts:

"We have bought a system which is flexible and providing we make parts within the size of the machines, we should be able to achieve our 80%. There will be times when we will go below that, we may have a lot of new work come in and we've got a lot of time in proving out so our downtime here will be doing prove outs initially because we're not running all existing work through it, we've got a lot of new work coming in. So we can't be running existing work because we're doing all prove outs for new jobs. You've got some delay, that happens, that's a fact of life, but it should only be short term."

This is not to deny that system utilisation did remain the most important objective for companies with "Mass Production" aligned objectives. Nor, as the comments above illustrate, that engineers at the other companies stopped striving to realise system utilisation (2). However, the important point is that engineers continued to allocate work to the FMS in ways that conformed with their initial manufacturing objectives.

The production department had responsibility for machining the parts which the engineer allocated to the system. They were expected to operate the machinery at the levels of performance

stipulated as acceptable by the engineer in the pre-investment justification, or according to subsequent revisions. FMS systems were generally set up as separate budget centres. That centre was allocated sufficient funds to purchase the resources necessary to process the volume and range of parts in the required batch sizes, and at the levels of efficiency, that had been stipulated in the pre-investment justification. Thus, the production department would receive batches of work to be machined on their manufacturing system as free time became available. When machining that work they were expected to expend resources at the rate specified in the pre-investment justification so that they could remain within their budgets. Each batch of work would be accompanied by instructions, provided by the engineer and his staff, of the machining operations to be performed. The production department would provide details of the work which they performed on the batch of parts and when for the benefit of the cost department. In some instances this information was taken from the system's computer.

The cost department had the responsibility for monitoring that FMS, and other systems, were performing to the standards that had been claimed for them. The cost department's personnel also had to identify the reasons for any failure to realise the standards sought. The main technique that they used for this was the flexible budget. The degree to which flexible budgets were formalised varied between companies. However, the general principle of their application was the same. As a means of demonstrating the operation of this form of cost control it is of value to reproduce part of the more formalised flexible budget documentation (see Exhibit 7.1) used by Diesel Engine Co.

Exhibit 7.1

Diesel Engine Co.
Direct Budget Centre Operating Plan

Budget Centre:

		Jan.	Feb.	March	April	Dec	Total
Standard	Budget						
M/c hours	Budget						
	Month						
	Actual						
	Variance%						
	Cum						
	Budget						
	Cum						
	Actual						
	Variance%						
Utilisation	Budget						
	Actual						
Operator	Budget						
	Actual						
Overtime	Budget						
	Actual						
Diversions	Budget						
	Actual						
Unmeasured	Budget						
	Actual						
Absence	Budget						
	Actual						
Directs	Budget						
	Actual						
Indirects	Budget						
	Actual						
Staff	Budget						
	Actual						
Directs/	Budget						
Indirect	Actual						
Hours Ratio							
Direct/	Budget						
Staff Ratio	Actual						
Cost Direct	Budget						
per	Actual						
Std. Hour							
Op. Exp	Budget						
	Actual						
Other	Budget						
	Actual						
Total	Budget						
	Actual						

As stated above, the production department would be allocated a sufficient sum of money to purchase the resources necessary to machine the parts at the level of efficiency, that the pre-investment justification had stipulated for a system. It is important to emphasise at this point that, whilst the facet of capacity monitored directly by the flexible budget was the level of system utilisation, the standard sought could be any proportion of system time. The precondition was that it had provided sufficient output and revenues at the time of the pre-investment appraisal to allow the system to be justified.

Clearly, the method of monitoring output, vis-a-vis the levels of system utilisation, is compatible with the process of monitoring described by critics of cost accounting. However, as outlined in Chapter Six the standards, in terms of the levels of system utilisation and the expenditure of other resources, stipulated in the pre-investment justification tended to vary. The corollary of this is that the levels of expenditure per unit of output allowed by flexible budgets also varied, according to whether the company had introduced their system for "Mass Production", "Flexible Manufacturing" or "Just-in-Time" purposes.

In the course of monitoring the performance of the department or system against the standards specified, the accounts department collects information from the production department on the expenditure of resources, such as the labour employed and the length of time that a system was in operation. The accounts staff also gathers information on the output from the system in terms of the batches that have been machined. If work had been allocated to the system in the exact mix of parts and volumes specified in the

pre-investment justification, and the system had been operated at the stipulated level of efficiency, the actual performance would correspond with the budgetted sum.

If there was some deviation from this scenario, the accounts staff could, by collecting information from the production department, see whether the deviation involved an increase or decrease in the use of particular resources. By examining the information gathered on the batches that were machined, the accounting staff could perceive whether the change, from the initial scenario, involved an increase or decrease in the levels of output. By cross checking the information from the department and on the batches, accounting staff could determine whether the changes in expenditure and types of output were proportionate to one another, or whether they were a consequence of changing levels of efficiency. They could also perceive whether the change originated in the production department or some other source. For example: whether there was an unaccounted change in the efficiency of set-ups and machining operations; or, whether there were bottlenecks elsewhere, changing mixes of parts, increases in development work due to changing markets, etc. Thus, it is only in the first instance that accounting staff investigate the levels of system utilization. If this is not as anticipated, the accounting personnel can investigate the other dimensions of performance that are monitored by the flexible budget. They can explore the legitimacy of any reasons for this before initiating corrective action, if necessary.

It is not intended to infer here that existing methods of cost control are ideal for monitoring FMS. They are not. The pre-

investment justification does not only express the capacity that a system was expected to attain, it also articulates the savings that FMSs are supposed to realise. The above discussion has sought to demonstrate that accountants are able to perceive whether FMS systems meet the desired levels of output along different dimensions of capacity. However, the flexible budget is unable to monitor all of the changes in consumption of resources that arise following the introduction of a new system.

The flexible budget focuses on the performance of a department. Many of the benefits that arise from some utilisations of FMS, such as reductions in some of the resources consumed, accrue elsewhere. A recap of the advantages that engineers included in their pre-investment justifications of FMS will help to clarify the nature of this disparity. Table 7.1 summarises the number of companies with particular motives that justified investment in

Table 7.1: Factors built into different Justifications of FMS.
Systems introduced for motives compatible with:
"Mass Production" "Just-in-Time" "Flexible Man."

Number of systems:	13	4	4
Grants	10	4	4
Replacement	5	1	1
Buildings	1		
Energy	1		1
Servicing	1		1
Tooling	1		
Overheads	1		
Labour	12	2	2
M/c times	3	1	
Sub-contract	3	2	3
Incr'sd Output	5		3
Indirect Lab.			1
Reduced Scrap	1		
WIP	3	4*	2
Interest	2	2	1
Intangibles		1	1

their systems against the attainment of specific benefits.

It is possible to classify the nature of the different advantages by a number of criteria. These indicate the extent to which the benefits were more or less visible and accessible to control by the flexible budget. Advantages may be classified as: one-off or ongoing - arising prior or subsequent to the point of inception of FMS - and, at the location of the system or elsewhere, either, at other areas of the firm or at the interface between the firm and the external market. The first category of savings reported in the table, grants, replacements and buildings, are "one-offs". These may arise prior to the introduction of FMS. For example, replacements for existing systems and buildings. Alternatively, they may be obtained at a definite point subsequent to the introduction of systems; for instance, grants. The determinate and single moment when the savings are obtained makes the realisation of these advantages easy to identify. Consequently, it is unnecessary for them to be monitored. The next group of advantages or savings shown by the table, ie, the list between energy and scrap, are ongoing and occur subsequent to the introduction of FMS. The departmental budget either states these savings explicitly, or, as in the case of machining times, sub-contract costs and increased output, they are implicit in the aggregate output performance that the system is expected to attain. They are also monitored as accruing at the location of the FMS. Whilst it is questionable whether savings in such factors as energy or overheads can be tracked unproblematically to a particular system, companies had specific calculations for linking their expenditure on these items to particular departments. For example,

these costs were often shared between departments in proportion to the numbers of machines in the department. Companies thus perceived this category of advantages accruing at the location of the FMS. It is these types of advantages that conventional methods of cost control are designed to monitor.

It is the next group of financial advantages of reductions in work in progress and interest incurred on the stock and Coal Co.'s "intangibles" which are the most difficult to monitor. They are both ongoing and occur subsequent to the introduction of FMS. It is, therefore, not possible to define a single and definite point when they materialise. Also, they do not accrue at the location of the FMS. Reductions in work-in-progress if they are achieved often materialise between different departments and not in them. The advantages, from increased market response and the winning of increased orders, embodied in the category of "intangibles" are partly manifest at the interface between the company and the market. Departmental budgets are not sensitive to the existence of the benefits.

It can be seen from the table that these types of advantages are most salient to the groups of companies that introduced FMS for reasons not aligned to "Mass Production". In this sense conventional cost control are incompatible with the novel advantages of FMS. There may be a danger that any failure to monitor some types of advantages could lead companies to compensate, by pursuing the benefits that can be monitored with greater enthusiasm than they otherwise would have done. This may lead to the misuse of FMS. This is an issue that will be addressed in the next section.

In summary, critics have argued that cost controls' monitoring of the volume of output and emphasis on machine uptime, encourages deployment of systems for ends that are contrary to a company's best interests. This section has explained that the apparatus used to monitor the performance of FMS compares with that described by the critics of cost control. That is, cost control does monitor the volume of output against the time that the system is operational. However, the apparatus for monitoring must not be confused with the standards that are monitored. The standards of output that are embodied in flexible budgets and expected from systems are derived from a company's pre-investment justification of FMS. These vary according to each firm's different manufacturing objectives when introducing FMS. The engineers at the respective companies allocate work to their systems according to the firm's manufacturing objectives. The accountants monitor the productive activity to ensure that the initial targets are being reached. The transfer of standards from the pre-investment justification to the flexible budget should, therefore, serve to promote pursuit of whatever manufacturing objective the company had introduced its system to realise. However, it has been suggested here that the failure of the flexible budget to monitor some of the novel savings and advantages associated with certain deployments of FMS could militate against this. The extent to which either factor influenced the deployment of FMS at the firms in their study will be examined in the next section by a comparison of the actual deployment of FMS systems with each company's initial manufacturing objectives.

7.4: Performance of Systems as measured by Companies Ongoing Cost Monitoring Techniques

Now that the strengths and weaknesses of cost monitoring have been outlined, it is possible to examine their impact by comparing the different systems' actual performance against those which were anticipated initially. The strength of cost control practices is their capability to monitor the output profile of systems. Their weakness is their failure to monitor the changes in the resource expenditure profile that takes place when systems are introduced for the purpose of either "reducing inventories", or "responding to markets for an increasing range of parts". At the close of the preceding section, it was suggested that these strengths and weaknesses could produce conflicting tendencies. Firstly, cost control could promote the use of systems for a company's stated objectives by projecting, and encouraging pursuit of, the initial output profile. Alternatively, by promoting the pursuit of an expenditure profile that does not facilitate realisation of the company's stated objectives, cost monitoring techniques could discourage companies from using their systems as they had initially intended. In effect, their inability to monitor one type of reduction in expenditure could result in pursuit of others as compensation.

In order to understand whether either of the trends were evident at the firms in this study, this section will examine the different companies' output and expenditure profile against those that were projected in the pre-investment justifications. The discussion will detail the output performance along the dimensions of capacity of system utilisation, range and batch size.

Explanations will be offered for any divergence between actual and projected performance. Details will then be provided of the companies' monitoring of the resources expended. In order to simplify the discussion on companies' monitoring of the expenditure profile of systems this section will detail examples only. Details of labour savings will be provided as a means of establishing whether companies were seeking to maximise savings on resources which were visible to compensate for being unable to monitor others. The response of companies that introduced FMS for "JIT" purposes to their inability to monitor reductions in inventories will also be detailed. It will then be possible to establish whether the overriding influence on the deployment of FMS is the ability to monitor output or the inability to monitor expenditure.

System Utilisation

Companies that installed their systems for ends aligned to "Mass Production" perceived the economic strength of FMS to be its capacity to machine the same type of parts in rapid succession to one another. Their objective was to reduce unit costs. Consequently, high levels of system utilisation were expected. Firms that had introduced FMS for other motives were prepared to sacrifice some system time, either for development work and changeovers when seeking to machine a wider range of parts, or to ensure that parts were only machined when required as a means of reducing inventories. Table 7.2 reports the levels of system utilisation that had been built into companies' justification of their systems and the levels which were subsequently realised.

The table reveals that companies that had introduced their

systems for reasons aligned to "Flexible Manufacturing" philosophy achieved similar levels of system utilisation to that which they had anticipated when composing their pre-investment justification. The systems at Nat Air., Alloy Corp. and Coal Co. had been justified against levels of utilisation of 80%, 85% and 80% respectively. All respondents reported that their systems had realised totals of around 80% utilisation. Only Diesel Engines' second system, which had been justified against 75% but realised 60%, failed to obtain levels of utilisation anywhere near the specified targets.

Table 7.2: Levels of machine utilisation expected and achieved with FMS.

Systems introduced for ends aligned with:

	"Mass Production"		"Just-in-Time"		"Flexible Manufact."	
	Desired	Achieved	Desired	Achieved	Desired	Achieved
95% + 1						
90% + 6		2				
85% + 1	2		2	1	1	
80% + 4				1	2	3
75% + 1	1				1	
70% +	4					
Other	4	2	2			1

Companies that had introduced their systems for reasons aligned to "Just-in-Time" philosophy also tended to obtain the levels of system utilisation that they had justified their system against. Miner Co. realised their desired level of utilisation and Small Machine Tool Co. exceeded their initial projections as a consequence of machining an additional part on their system. At Print Co. the company reported that the system had not been installed a sufficient length of time for them to assess whether

their initial failure to realise the desired levels of utilisation was a transient phase or a settled pattern. Only Soot Co. reported that they had failed to attain the level of utilisation against which the system had been justified. The reason given for this was that demand for their products had not fully recovered from drops in orders from their major customer, British Coal, after the 1984-5 miners' strike. Thus, cost control mechanisms do not appear to be encouraging these companies to use FMS for purposes other than those which the systems had been purchased for.

Firms with motivations aligned to "Mass Production" reported the greatest divergence between the levels of utilisation that FMS had been justified against and those which were realised once the systems were operational. Only a small number of companies regularly achieved the levels of system utilisation that they had originally anticipated. These reductions were not desired by the company, nor were they organised responses to information generated by cost control. The companies would have preferred to realise the levels of system utilisation specified in their pre-investment justification. However, two factors prevented them from doing this.

Firstly, the markets that the companies catered for changed between the times when the systems were initially proposed and subsequently introduced. As a consequence the affected companies had to adapt their systems to machine different types of work. For example, at Coach Co., the FMS had been justified against its manufacture of the parts for a new gearbox for a new range of coaches. However, in the interim period between the system's purchase and installation, the Government had deregulated the provision of local transport. The demand for the new model of small

coaches from regional transport authorities failed to materialise and the company's FMS had to be turned to alternative uses. Despite subsequently taking on sub-contract work, the firm failed to use all of the system's machining time.

A similar scenario was experienced at **Small Motor Co.** FMS had been purchased because it allowed the company to machine, to tighter tolerances, the large volumes of parts for a new gearbox that was planned by their major customer. When the customer decided not to go ahead with the new model, **Small Motor Co.** attempted to adapt the system to machine the parts for another new contract. However, they encountered technical problems because the parts for this second contract were too large to be loaded by the system's robots. Manual loading of parts resulted in the lower levels of utilisation.

Technical problems were the second set of factors which militated against companies' realisation of their desired levels of system utilisation. At **British Machine Tool Co.** and **Diesel Engine Co.** the problems were caused by failings in system design. These two companies systems suffered from the respective problems of limitations in routing flexibility and insufficient buffer areas. These led to low levels of utilisation, particularly from third, fourth and subsequent operation machine tools. **Boiler Co.** also realised lower levels of system utilisation than they originally anticipated. This was a consequence of the FMS overheating when burrowing the immersion heater lids which the company were machining. Problems with software management and assimilation prevented the desired level of utilisation at **Marine Co.** Finally, **Trans Co.**'s system also failed to realise the desired levels of

utilisation. However, the company's personnel explained the main cause of the shortfall as the poor quality of the raw castings received from suppliers. This, allegedly, led to the system's difficulty when aligning the castings in preparation for operations.

In summary, there was a high degree of correspondence between the levels of system utilisation which a company embodied in their pre-investment justifications and that which was subsequently attained once the FMS systems were introduced. This correspondence was most clear at firms that had introduced systems for "Flexible Manufacturing" and "JIT" objectives. A similar pattern was less apparent at firms that had introduced systems for "Mass Production" objectives. However, the respondents explained the failure of their respective systems to realise the desired levels of utilisation as an undesired consequence of changing markets and technical failings. There was no evidence to suggest that the pattern was a consequence of the application of inappropriate cost control techniques. It is interesting to note that in one of the few instances where there was an increase in the levels of system utilisation obtained, at Small Machine Tool Co., this was accompanied by an increase in the range of parts machined. It was not the outcome of a cost control led retreat from flexibility.

Range of Parts Machined on FMS.

Whilst all of the companies had purchased FMS because it offered the capability of machining a range of parts, the size of the desired range varied according to a company's manufacturing objectives. Firms that had introduced their systems for reasons aligned to "Flexible Manufacturing" philosophy had anticipated machining ranges of parts wider than those sought by companies that had introduced their systems for other purposes. The size of the range of parts that the systems were purchased to machine and the actual range on the respective FMS systems are summarized in the table 7.3.

Table 7.3: Range of parts desired and obtained from the different systems.

Firms motivated to introduce FMS by reasons aligned to: "Mass Production" "Just-in-Time" "Flexible Manufact."					
Range of parts:		Desired	Achieved	Desired	Achieved
2 - 10		2	1		
11 - 20	5	3	1	1	
21 - 30	4	4	1	2	
31 - 40		1	1	1	
41 - 50	2	1			
51 - 75	1	2			
76 - 100	1				1
101 - 200				1	
200 +				3	3

The table shows that the companies that introduced their systems for reasons aligned to "Flexible Manufacturing" did succeed in loading a wider range of parts onto their systems than companies in the other groups. The range attained tended to be similar to

that which these companies had anticipated in their pre-investment justification. There was one exception to this. At Diesel Engine Co. the system had failed to realise the level of utilisation desired by the company. As a consequence it was unable to machine the aggregate number of parts that the company had hoped for. The demand for parts from a proportion of the range that was initially intended for the FMS filled the available machining time. Consequently, the company scaled down the number of different parts that they loaded onto the system. The retreat from flexibility was, therefore, proportionate to the retreat from productivity and not the consequence of an increase in the latter, arising from the application of cost control standards.

There was also a degree of congruence between the range of parts machined on systems that had been introduced for "JIT" aligned objectives and the range which the firms had initially anticipated machining. There were, however, two firms in this group that expanded their range of parts. This was a consequence of them having excess capacity. As reported above the demand for Soot Co.'s products had dropped in the course of the 1984-5 Miner's strike. At this point the company added to the range of parts manufactured on the FMS by machining sub-contracted work. Elsewhere, at Small Machine Tool Co., the increase in the range of parts, in addition to those that were originally intended for the FMS, arose out of the company's pursuit of "JIT" objectives. The company had built their own FMS in-house and this had proved to be inexpensive. The introduction of the system also facilitated substantial reductions in work-in-progress. These two factors allowed the firm to justify their system against a low level of system utilisation which

provided them with surplus capacity. They used this to develop a variant of their major product.

There was a degree of variation between the range of parts that were actually being machined by, and those that had been intended for, systems introduced for "Mass Production" aligned purposes. Some companies increased their range of parts whilst others reduced theirs. The changes in use were not consequences of preemptive rejections of original aims arising out of deliberations on the findings of cost control. They arose out of attempts to fill the systems' available machining time, after circumstances had changed, once the companies had decided to purchase FMS. Four firms produced a more limited range than they had originally intended. At one company, Boiler Co., part of this retreat from flexibility had been anticipated. Both British and European markets were catered for. The British markets had been organised around a large number of old imperial sizes whilst the European market demanded a smaller number of metric sizes. The company's plan, prior to the introduction of the FMS, was to phase out the imperial sizes gradually. FMS had been purchased because it allowed the company to do this. However, this was not the only reason for the reduction in the range machined. Like the other three companies where there was a retreat from flexibility, the total volumes of the range of parts initially intended for the system could not be machined on the system. At Industrial Vehicles Ltd. and Trans Co., this was because markets were expanding. At Trans Co., Boiler Co. and Diesel Engines Ltd., it was because technical problems prevented realisation of the anticipated level of system utilisation. The companies responded to this excess of demand over capacity by limiting the

range of parts, that were machined on the system, to that which was necessary to fill the system's time. Thus, the retreat from flexibility tended to be proportionate to the fall in the productivity of the system.

A large number of the remaining companies in this group, ie, Coach Co., Dual Air Co., Brit Machine Tool Co. and Small Motor Co., were using their systems to machine a wider range of parts than they had originally anticipated. This was a consequence of an excess of system time after the company had machined all of the range of parts that they had initially intended to put on the FMS. In all instances this had been caused by loss of markets and contracts which necessitated that the companies sought new work.

In summary, there is a high degree of correspondence between the ranges of parts that companies initially intended to manufacture on their FMS systems and those that they machined subsequently. As with levels of system utilisation, the correspondence was greatest amongst firms that had introduced their systems for "Flexible Manufacturing" and "Just-in-Time" aligned objectives. The changes in the sizes of range machined at companies with "Mass Production" aligned objectives were not caused by preemptive rejection of the companies initial manufacturing strategies. They were the consequence of changing markets and technical problems.

Batch sizes.

Whilst the ability to machine in definite batch sizes was an important capability for all companies that purchased FMS, it was of greatest importance to those firms that had installed their

systems for purposes compatible with "JIT" philosophy. These perceived the economic advantages of FMS resting with the reductions in stocks that would otherwise have been left idle if parts had been processed in large batches. The ability to manufacture in definite batch sizes was also important to firms with "Flexible Manufacturing" objectives. The economic advantages of machining new parts demanded by customers without purchasing a new system is contingent on machining time being made available. Machining in small batches, as and when parts are required, frees system time for new purposes.

Most of the companies that introduced systems to realise "JIT" or "Flexible Manufacturing" related objectives wanted to be able to machine in batch sizes of one. Firms that introduced systems for reasons aligned to "Mass Production" were prepared to machine in larger batch sizes. Table 7.4 compares the batch sizes that companies built into their pre-investment justification of FMS with those that were achieved subsequently.

With the exception of one firm in each of the two groups all of the companies that had introduced FMS for purposes aligned to either "Flexible Manufacturing" or "Just-in-Time" objectives did machine in batch sizes of one. Therefore, it does not appear that cost control distracted companies from their initial intentions. The two exceptions did machine some parts in larger batch sizes, partly because they believed it was more economic to do so. Obviously, this may be interpreted as cost monitoring wrongly encouraging the companies to pursue the mass production related objective of reducing unit costs. However, there are good reasons for doubting that this was the case. It was Nat Air., from the

group of companies that had introduced FMS to realise "Flexible Manufacturing" objectives, that machined some parts in larger batch

Table 7.4: The batch size of parts desired and obtained from the FMS.

Firms motivated to introduce FMS for reasons aligned to:						
"Mass Production" "Just-in-Time" "Flexible Manufact."						
Batch size:	Desired	Attained	Desired	Attained	Desired	Attained
One.	(1).	(2)	4	3	3	2 + (1)
2 - 5				1		
6 - 10						1
11 - 20						
21 - 30		2				
31 - 40		2				
41 - 50	6	3			1	1
51 - 100	5	4				
101- 200	1	2				

Above 1

() indicates capability not economically applicable to whole of range.

sizes. The range of parts that was loaded onto the FMS tended to vary in size and cycle time. It was only economic for the company to machine some of the small low value parts, that had short cycle times, in batches of ten or more. This allowed simultaneous use of other tools in the system to machine larger parts in batches of one. Loading the smaller parts in tens was, therefore, a means to the simultaneous attainment of the flexibility in the system by the concurrent machining of others in batches of one. **Small Machine Tool Co.** from the group of companies that had installed their system for "JIT" purposes was the exception that did not machine in batch sizes of one. Instead parts were machined in two's because

the pattern of demand and set-up times made this the most viable option. Given that this firm had expanded the range of parts on their system it is difficult to sustain an argument that the increased batch size represented a retreat from flexibility.

Systems that were introduced for "Mass Production" aligned objectives were most likely to be used to machine parts in batch sizes different to that which had been stipulated in the pre-investment justification. One company, Trans Co., had reported that they wanted the capability to machine in batches of one, and claimed to have achieved it, although it was not a facility that they used. One other company, For Machine Tool Co., reported that the recession in the engineering industry had left them in a situation where they could not always fill their FMS. In these circumstances they were prepared to use the FMS to machine one-offs for their own product range if necessary. However, this was not an economic option and not one which they were be prepared to enter into on a sub-contract basis.

A number of other companies in this group did reduce the batch sizes of parts from that which they had anticipated when justifying their system. However, the impact of cost control had no direct bearing on this change in deployment. Companies' loss of markets had left them with excess capacity. The work which they found subsequently to fill their systems was demanded in smaller sized batches. This situation occurred at Coach Co., Dual Air Co., Brit Machine Tool Co., Small Motor Co. and For Machine Tool Co.

In short, there was a degree of comparability between the batch sizes specified in pre-investment justifications of FMS and those which companies subsequently attained. There were some

reductions in batch sizes amongst firms that introduced FMS for "Mass Production" aligned objectives. This was a consequence of loss of markets for large batch work rather than a rejection of the belief that the strength of FMS rests with its capability to machine in large batches.

Levels of Staffing on the FMS vis-a-vis original projections.

The number of staff employed typifies the resources which flexible budgets are able to monitor. Financial and managerial staff simply count the number of workers employed. As was detailed in Chapter Six, companies that held motives aligned to "Mass Production" philosophy were more likely to justify their introduction of FMS against the labour savings that it facilitated. Table 7.5 summarizes the amount of labour that companies with different motivations employed on their FMS vis-a-vis their initial projections.

Table 7.5: Extent of attainment of projected levels of staffing on FMS.

	Less Labour employed	Same Labour employed	More Labour employed	Other
Firms that introduced systems for reasons aligned to:				
"Mass Prod." 1	6		5	
"Flex Man."	3		1	
"JIT"	2		1	1

The table reveals that companies with motivations aligned to "Mass Production" were most likely to employ additional labour to that which they had originally anticipated. However, the firms' personnel maintained that their initial projections of labour use had been correct. One of two reasons was given for the increase.

First, the additional staffing employed was reported to be a temporary arrangement. At Marine Co. the employment of extra staff was explained as the induction of trainees who would provide cover for absences. Also, at British Machine Tool Co. the company reported that the additional staff employed on FMS were being trained in preparation for a return to shift-working.

The second reason that companies gave for the increased levels of staff employed was their inability to realise full utilisation of the system, with the original number of workers, when the circumstances initially anticipated had failed to materialise. At Trans Co. up to four extra operatives were employed, partly as a result of the expansion in the size of the system, but mainly as a consequence of the poor quality of the raw castings. Elsewhere, at Small Motor Co. loss of markets led to the redeployment of FMS for the machining of a range of parts that were bulkier than those originally designated to the system. Two extra operatives had to be employed to load the components until the system's robotic loaders could be adapted to this purpose. Finally, at For Machine Tool Co. an additional operator was employed on occasions depending on how the system was being used. The changes in use after initial markets were lost was also the reason why Coach Co. did not use the level of labour they had initially designated to the FMS. The company had failed to fill the system and consequently did not employ the same numbers of workers.

Companies that had introduced FMS to pursue objectives that were not aligned to "Mass Production" philosophy were more likely to employ the levels of labour they had initially designated to the system. This appears to be a consequence of their initial

employment of a higher level of staff rather than a more rigid pursuit of controlling the consumption of labour. We have already seen that firms in these groups tended to realise their stated manufacturing objectives. What is more there was evidence that extra labour would be employed if necessary to realise the objectives for which the FMS system had been introduced. At Scot Co., where FMS had been introduced for reasons aligned to "Just-in-Time" philosophy, an extra worker per machine tool was employed because the company had been unable to achieve the adaptive control that had been anticipated, when the system was purchased.

Elsewhere, at Nat Air Co. where FMS had been introduced for reasons aligned to "Flexible Manufacturing" philosophy there appeared to be relatively little concern about putting any viable controls on the sum of labour expended. Extra staff were employed on the FMS because the company had not yet merged jobs that they had intended to. (See Jones and Scott (1985: 91-2) for fuller discussion of this firm's attitudes towards the attainment of labour reductions.)

In summary, companies that introduced FMS for reasons aligned to "Mass Production" philosophy had been most likely to justify their systems against reductions in labour. However, they often found that it was not possible to realise their anticipated savings because of technical problems when operationalising systems for new uses after markets had changed. Companies that had introduced FMS for other purposes were more likely to use their systems for their original objectives and employ the same level of staffing as they had forecast in their pre-investment justification. There was no indication of firms pursuing reductions in labour to compensate for

any inability to monitor the realisation of other advantages.

Monitoring of Inventory savings.

Inventory savings are an example of the types of advantages that a company may realise as a consequence of introducing FMS but which cannot be monitored by flexible budgets. This is because, the reductions in stock do not materialise in the departments where systems are installed. An inability to monitor inventory savings might have been expected to lead to companies seeking to increase other traditional types of gains as compensation. This in turn could lead to the mis-use of FMS. However, as we have seen in the preceding sections this was not the case. Inventory savings figured most prominently in the justifications of systems introduced for "JIT" purposes. It is of value to investigate the responses of these companies to their inability to monitor inventory savings in order to gain an insight into the exact consequences of the weaknesses in cost control.

It must be stated that the potential conflict between accounting staff and engineers over novel benefits were most likely to arise at the time of the pre-investment appraisal. Financial staff had been wary of including inventory savings in the justification of a new system because of the risk of double counting. The Financial Director at Print Co. explained this problem, thus:

"this particular system (the FMS) has been justified on its own merits and the sort of savings that could mainly come out of it is back to inventory again. But, this is the old, old problem. You know you could find that with inventory savings of £2 million here on this project and £1 million there on that project, a

total of £3 million. You could soon find out that you end up with negative inventory if you're not careful."

In contrast to this, the engineers' concern was not that inventory would be double counted, but that it would not be recognised at all, once the system was installed. The Production Engineer at Small Machine Tool Co. explained:

"when you look at a machine component purely looking at cutting times, you don't get the full benefit of an FMS. The benefit of an FMS is the reduction of lead times which when it's fitted into a costing exercise in the pure sense it does not come out. So sometimes you have got to keep your accountants off those types of calculations."

It will be recalled from Chapters Five and Six above that no systematic financial appraisal of FMS had been carried out at Small Machine Tool Co. Thus, initial identification of the reductions in inventory, the winning of accountant's approval for their inclusion in the pre-investment justification and the verification of the realisation of inventory savings remained a limited problem. This was also the case at Miner Co. where the directors had initiated the introduction of FMS. The accountant's independent role in the pre-investment evaluation process had been precluded by the directors' initial justification of FMS and quantification of inventory saved. This appeared to make it less imperative to monitor that the anticipated reductions in inventory had been realised. The following is an extract from a conversation with the Production Engineer and System Manager, Simon and George. It illustrates that they were satisfied that the inventory savings had been realised even though no attempt had been made to substantiate this. The FMS had facilitated a general reduction in the number of

operations in the manufacturing process and this allowed them to employ a self-serving calculation to provide a legitimation for the existence of the savings.

Simon: "Nobody has done any calculation on work-in-progress and stock in any sort of detail but its obvious if you like that we've introduced a part here and it can be machined in an hour and a batch of one hundred could be machined over a day or two. Whereas before it would have been hanging around in baskets waiting to go on a machine which might not be available for a while and a number of machines were also required to get the same number of ops. out of it. Generally, work-in-progress is down to days if you like."

George: "Really, the way that we're working out the work-in-progress is the lead time for a component is 1.4 weeks x the number of operations. So in the past we might have six or seven, up to twelve operations on any component. And the volume of work-in-progress would be the number of operations x 1.4 x the components as they moved right through the shop and into assembly. Now because the system can reduce the operations down to one or two you're reducing your work-in-progress by the ratio of operations we're taking out."

The impact of not monitoring inventories was felt more acutely at those companies where the production engineer had proposed the introduction of FMS. For example, at Soot Co., the FMS had been set up as a separate facility in a budget centre of its own and with a separate overhead cost, to reflect the heavy expenditure in the FMS. When comparisons were made between the cost performance of FMS and other systems, FMS appeared more expensive because the company measured only the expenses incurred in the department. The production engineer explained:

"I'm speaking as a production engineer, and I have to say that I'd criticise the way that our FMS is monitored. They're monitoring the costs

of the output say on a monthly bases, X number of units per month. They're monitoring the costs and they compare these costs against what they'd take to produce these on a conventional machine, and that's all they monitor. So the bottom line sums does not take into account the savings in manning, or the savings in inventory. I'd have thought that you'd start from where you had spent X amount of money and you'd get credited for the value of what you're saving in work-in-progress and you'd get credited with the savings that you had made in manning, and then the remainder. Then, whatever you're producing you should be getting it based on that bottom line figure rather than the topline figure."

Despite his grievances over the costing system the respondent did report that the calculations did not affect the allocation of work to the FMS. The company's flexible manufacturing system simply appeared as inefficient vis-a-vis other systems and this was to his detriment.

It is clear from the inclusion of inventory savings in the pre-investment appraisal that accountants were willing to accept engineers assertions that FMS would facilitate financial gains through reductions in the stocks carried. However, the failure of departmental budgets to articulate such savings does result in a potential conflict, between accountants and engineers, at the cost monitoring stage. This is related to the accountants and engineers different responsibilities and location in the enterprise. The production engineer is aware that the inventory has gone from one department. The accountants felt that this was not proof that it had not been transferred to another part of the organisation. The production engineers had an interest in the savings being registered. It was they who had defined the economic viability of FMS in terms of the inventory saving and it was they whose careers

were on the line, if the system did not appear to the observer as economically viable. The accountants, on the other hand, would be put in a tenuous position if overall profitability and return on investment were to drop, as a consequence of a number of investments not giving financial performance the boost which they had initially anticipated. Thus, they had an interest in not taking the actuality of these savings on the word of a production engineer. As has been reported above, these pressures were alleviated to a large extent in those companies, such as Miner Co. and Small Machine Tool Co., where directors had initiated the introduction of FMS and could hold no-one but themselves responsible if the investment proved to be an economic failure. But this was not the case at Scot Co. or Print Co.

This problem did not lead accountants to deny without evidence that the reductions had been attained once the system was installed. Nor, as we saw above, was there any evidence that an inability to monitor inventories was leading to a change in manufacturing priorities and the pursuit of other gains. It will be recalled from the earlier part of the discussion that it was engineers who had justified the system and continued to allocate the work to the FMS, in accord with the principles that had been embodied in the pre-investment justification. The role of the accountant was to ensure that the systems were used efficiently when pursuing that objective. In other words, they had to find ways of monitoring the deployments of FMS that existed and not to find deployments of FMS that they could monitor. This led to plans to change the method of monitoring at Print Co. so that the company could identify the existence or otherwise of reductions in stocks.

The financial director reported that the company was in the process of installing Manufacturing Resource Planning II (MRP II). This is a system of scheduling and allocating parts when needed by identifying (a) the products to be manufactured; (b) the parts which were needed for this production; and (c) from where and when the parts were to be taken as defined by an individual bill of materials for each product. It provides information on exactly where each product is in the production stage and, by extension, the size of inventories in each area. The company hoped that when they had installed this system, it would allow them to assess how FMS and any other new future purchase helped in the reduction of inventories. The accountant at Scot Co. had been appointed just prior to this fieldwork being conducted. He also reported that he might initiate changes to the techniques of monitoring the FMS once he had a fuller appreciation of the company's manufacturing operations.

In summary, inventory reductions, that were used to justify the introduction of FMS systems for "Just-in-Time" objectives, provide an example of the types of novel advantages that the cost control methods of flexible budgets are unable to monitor. Accounts staff tended to respond to this failing in one of two ways. When directors had initiated the introduction of FMS realisation of savings was accepted without question. When the production engineers had initiated the introduction of FMS, the accountants sought ways of confirming the realisation of inventory reductions.

Summary.

This section has investigated how the pattern of deployment of

FMS systems that were introduced for purposes aligned to "Mass Production" "Flexible Manufacturing" and "Just-in-Time" philosophies compared with the performance that was anticipated from them when their initial pre-investment justifications were prepared. The objective has been to examine whether the evidence suggests that cost controls' capability to promote realisation of a company's initial objectives, by projecting the desired output profile, is outweighed by the inability of cost monitoring to track the accompanying patterns of expenditure. The overriding pattern is that variations in deployment tend to approximate those anticipated in the pre-investment justification. This suggests that the most important impact of cost monitoring on the deployment of FMS is the definition of output capacity. This is derived from the pre-investment appraisal.

This conclusion is not contradicted by either the findings of this research, at the companies where the actual use of FMS differed from that which was initially intended, or the findings on the effect of cost control's inability to monitor expenditure profiles. On the first count, the only group of systems that were used for purposes other than those stated in their pre-investment justification were the FMSs which were introduced to meet "Mass Production" aligned objectives. The decreased levels of machine utilisation of these systems indicates a fall in productivity. The companies themselves reported this to be a consequence of losing old markets.

On the second count the example of labour showed that, whatever other resources companies are failing to monitor, firms are not seeking greater reductions in labour to compensate. The

example of inventory reductions demonstrates that a firm's inability to monitor changes in the expenditure of resources expressed in the pre-investment justification results in either, a simple acceptance that the changes have taken place, or a search for ways of monitoring the existence of promised savings. It does not lead to a rejection of the deployment that gave rise to the advantages in the first instance.

This suggests that it is wise to conclude that the main variation, in deployment of FMS systems, between companies is a conscious and deliberate one which originates prior to the installation of the systems. In other words, the systems tend to be used in accord with the motives that the engineers gave for purchasing the systems. Regardless of the weaknesses in accounting practices the transfer of the definition of capacity, from the pre-investment justification to the cost monitoring apparatus, serves to promote the realisation of a company's initial manufacturing objectives.

7.6 Audits.

Before concluding this chapter, it is of value to report the influence of one set of cost monitoring techniques, audits, which have been ignored by many discussants of the impact of accounting on FMS. Like other methods of cost monitoring, audits compare actual events with the scenario projected in the pre-investment justification. They use the same information as ongoing cost control. Where they differ is that they attempt to take a longer term view of the performance of a system. Two different types of audits were reported at the companies in this study: (a)

expenditure audits; and (b) performance audits. The extent of the influence of each on the deployment of FMS will be discussed in turn.

(a) Expenditure Audits.

Theoretically, expenditure audits are important to the deployment of FMS. If they restrict the cash spent on a system they may prevent the investment necessary to expand its range of uses. The need for expenditure audits was pre-empted at a number of companies, particularly those firms with "Mass Production" aligned objectives, as systems had been installed as turnkey packages. Purchasing companies' contracts with the suppliers of FMS included initial programming costs. Of the remaining companies, only one firm, Print Co., assembled a structure that allowed monitoring and control of their expenditure on the installation of FMS. Their motivations for doing this was that their FMS systems was one of the most expensive configurations installed. Whilst a total budget was set aside for the system as a whole, with someone appointed to supervise the expenditure, its main elements were justified, and supplied, separately as six individual items. The total budget, and the expenditure audit, allowed the company to ensure that the system, and its cost, did not grow out of reasonable proportion and that each item was reconciled with the total system. At the remaining companies where systems had been "home grown" reports of expenditure on the FMS exceeding initial projections were commonplace. The prevalence of turnkey packages, the relative absence of expenditure audits and the evidence of overspending, suggests that in-house expenditure audits have had little influence

on the deployment of FMS.

(b) Post-installation performance audits.

Post-installation performance audits probably have the greatest potential of different types of audits to influence the pattern of deployment of FMS. Firstly, they allow the company to establish the value of their investment and this may influence the extent of subsequent investments in similar systems. Secondly, they may lead to changes in how the system under investigation is deployed. However, a number of authors have suggested that the influence of audits on the deployment of FMS is minimal. Different writers have reported that audits of FMS have not taken place, either because of a company's inability to monitor the non-productivity gains of FMS (Finnie, 1986), or because of the potential opposition of the personnel who championed the introduction of the system in the first instance (Bessant and Haywood, 1987).

These arguments fail to recognise that many companies did not anticipate non-productivity gains from FMS (see Chapter Six above) and the actual merits of a system, and the competence of its champion, are likely to be indicated by ongoing cost control long before any audit is carried out. What is more, it is difficult to perceive why executives would be prepared to tolerate failure to comply with formal practices, such as audits, which are designed to help monitor the continued profitability of a company; especially if that profitability appears to be threatened. Therefore, a more detailed account of the influence of audits and an adequate explanation of why they are not always applied is necessary.

Part of the reason why audits have not been applied in some instances is because, historically, they had not been a normal practice at the companies studied. Only ten firms that had introduced a total of eleven systems reported that full post audits had historically been part of their normal procedures. These were generally conducted between 18 to 30 months after the initial installation of systems. Two additional firms, **Scot Co.** and **Boiler Co.**, reported that they carried out interim audits. Finally, in two other companies, **Motor Co.** and **Diesel Engines Ltd.**, audits were reported to take place only as the company thought necessary. Thus, 14 companies in all, that had introduced a total of 16 systems, reported that performance audits of one form or another were facilitated by their normal procedures. This left five companies, **Trans Co.**, **Miner Co.**, **Small Motor Co.**, **Gear Co.** and **Small Machine Tool Co.**, where it was reported that no system of audits existed prior to the introduction of FMS. Not surprisingly, the majority of these, **Trans Co.**, **Small Motor Co.** and **Small Machine Tool Co.**, were drawn from the group of small independent companies.

Preceding customs were not the only factor that influenced whether audits were conducted. Often changes in the nature of the organisation precipitated audits where they were not initially anticipated and precluded the conduct of others where they had been intended. For example, a large corporation had taken over **Small Motor Co.** and instigated new accounting procedures (see section 5.3 above). The new accountant anticipated that at some time in the future a post audit would be conducted on the FMS. In contrast to this, audits had been reported as regular features of the practices at **Nat Air Co.** and **British Machine Tool Co.** but were unlikely to be

performed on the FMS. At both companies there had been organisational or procedural changes subsequent to the introduction of the systems. As a consequence FMS had fallen between the two stools of the old procedures and organisations and the new. It had been unaffected by either.

The absence of audits at other companies did not preclude the individuals in the firms from developing monitors which they felt allowed them to report the general performance of their system. For example, at Trans Co. extensive modernisation had taken place. As the FMS was just a small part of this, the company's accountant was unwilling to isolate its individual contribution as separate from the other developments. Instead he monitored the aggregate effect of all the investments by changes on general performance indicators - such as returns on total capital employed, the level of the general overhead rate and overall machining times.

The consequence of historical legacies, changes in the companies' organisation and the development of alternative monitors, was that checks that purported to reflect the overall contribution of FMS to the company had, at the time of this research, been performed on only nine of the twenty-one systems studied. Scot Co., Dual Air Co., Trans Co., For Machine Tool Co., Boiler Co., and Coal Co. had all audited their respective systems. Industrial Vehicles Ltd. had audited both of their systems and Diesel Engines Ltd. had performed an audit of their first FMS. (See table 7.6.) It must be stated that in no instance was it reported that the audit had led to a change in the beliefs of a company's personnel, about what constituted the manufacturing strengths of FMS, or a rejection of a company's central manufacturing

objectives.

Part of the explanation why some companies had not conducted performance audits of FMS, when such practices had been part of their normal procedures, is because insufficient time had lapsed

Table 7.6: Extent of intent and conduct of performance audits.
Anticipated checks on Actual Checks on system.
system.

No post expend- iture checks:	5	
Post-Inst. performance audits.	11	4
Interim Performance Audits.	3	2
Checks other than audits:	2	4

since the system's installation. However, another reason was that no-one had a great interest in conducting the audits. This is because audits carry costs but promise little other than the amplification of the findings of ongoing cost control. That is to say, they use the same information to compare the system's performance against the same standards specified in the same pre-investment justification. If ongoing cost control suggests that the FMS is not performing satisfactorily, the accountant may initiate a full audit to clarify the nature of the drop from the previously defined standards. If ongoing cost control indicates that the system's performance corresponds with the anticipated standards, accountants and executives may leave engineers to assess the value of a system when they see fit. Two examples from this study, For Machine Tool Co. and Diesel Engine Co., will serve to illustrate

that when audits are published, their purpose is to amplify the findings of cost control. However, publication of the findings of those audits are precipitated by extraordinary events.

For Machine Tool Co. like many other engineering companies suffered from the economic recession in the 1980's. Falling demand left the company with surplus capacity. The Production Engineer who had the responsibility for proposing FMS generally conducted the audits of the investments. As explained in Section 7.3 above the engineer also had responsibility for deciding which system should be used to machine different types of work. As he had excess capacity he had more latitude in allocating parts to different machines according to different criteria. What is more the company machined parts for their own range of products as well as for work contracted to them by others. Contracts for others had definite prices but the value of parts machined for internal purposes were not always specified. Thus, the engineer enjoyed a degree of freedom to allocate and omit to allocate work in ways that would embellish the apparent performance of FMS.

When asked for details of his recent post-audit of FMS, the Production Engineer reported his aggregate findings against those which had been projected in the pre-investment justification. The personnel from the cost department were also present in this interview and the production engineer refused to reveal the full breakdown of the findings. When pressed to expand on one aspect of the details of the initial financial justification, he admitted that there had been greater expenditure in this one area but added that this had been compensated by an accrual of additional advantages/ savings elsewhere. The engineer had, in performing the

audit, provided a legitimization of his earlier decision. He also had information which he could use to demonstrate his competence to his superiors when necessary. The general lack of demand for the company's products meant that he was placed in a situation where he could claim that he was using the system to the best possible effect.

The cost departments personnel's subsequent comments illustrates that they perceived the engineer's conduct of audits as a process of selection and omission which was, at best, a distorted picture of the reality that it sought to represent. They found this acceptable in the situation of low demand, as long as it did not pose a threat to the company's profitability. Their protection against this was vigilance in ongoing cost monitoring and it was anomalies indicated by this, that would precipitate action by them. One member of the accounting staff said:

"in good faith judgements and predictions can go wrong. You heard Brian saying that the 11% was proven right, not because it was spot on in the first place, but because there was some overspending but we got more production. I mean OK you don't really believe that it came out exactly at 11.14% and he said that: "Well, that was lucky." I don't know which one he found out first, I suspect he found out the overspending first and then panicked, and then just found, it was convenient to say that we had more production. OK, that sort of thing is something that you need to be sure of because you can be coming along with an overhead recovery rate that may not be in anywhere near the truth and you may be going out to Massey-Ferguson and saying £25 an hour, deal. Now if it's costing you £30 an hour that's bad news, you're subsidising Massey-Ferguson tractors."

The events at For Machine Tool Co. contrasts with those at Diesel Engine Co. It was at the latter where the managing director had instructed the production engineer to submit proposals for FMS.

The production engineer proposed a system using only traditional dimensions of performance. Some of the claims that he made were extravagant in the extreme. For example, he justified the system on 7-day, three-shift operation when, to the accountant's knowledge, a new shift pattern had not been considered; at least, not to the extent of discussing it with the trade unions. On other dimensions of performance, expectations were not excessive. For instance, the FMS was justified against only 75% machine utilisation. The anticipated performance of systems at some other companies had been 90% and above. (See Chapter Six for full details.) However, the FMS had been developed in-house and poor design and technical problems prevented it from ever reaching these levels of performance. Similarly, the machining times of parts were never realised. The exact reason why the problems were never resolved is unclear. The engineer's knowledge and commitment to the system might be questioned. However, it was clear that he felt there was little practical support for FMS amongst his superiors. He bemoaned his directors failure to make money available to develop the system to its full potential even though they spent money servicing cars for their own use. It is difficult to assess the validity of his complaints as the accountant also reported that there had been significant over-expenditure in the purchasing of the FMS.

The general market situation of the company did not serve to obscure the poor performance of the FMS. The FMS had been set up as a separate cost centre. As already noted, it was justified on traditional criteria. The continuation of the markets for parts which the system was justified against, enabled the accountant to see exactly what was going into the department and what was failing

to come out. The FMS's failure to machine at the pace which had been claimed in the justification resulted in large volumes of work, which should have been brought back in-house, still being sub-contracted out one year after the system had been installed. At the same time other forms of expenditure had risen to above that anticipated by the initial justification. This precipitated the conduct of an interim audit by the accountant. The main findings of this was that: levels of system utilisation were only 17% based on the seven-day working which the system was justified against or 23%, based on the five day week which it was actually operated; and net savings in sub-contract costs were one-sixth, £25,000 per annum, of those that had been anticipated. This led to the setting of some interim targets for the system to meet in order to improve its profitability. The audit was, thus, a means of amplifying the findings of ongoing cost monitoring techniques which indicated that work was not being processed at the speed at which it should have been.

In summary, critics of accounting practices have given insufficient attention to the impact of performance audits on the deployment of FMS. This section has reported an uneven pattern in the conduct of audits. Some firms have not, historically, conducted audits and organisational changes have led others to deprioritise their utilisation. It has been contended here that when audits are conducted they are used as amplification techniques to elaborate the findings of ongoing cost control. Contrary to the arguments of other authors, this appears to be the reason why they have had little impact on the deployment of FMS.

7.6 Conclusion.

The objective of this chapter has been to explain the influence of cost control on the deployment of FMS systems introduced for the purpose of either: "increase or maximise machine utilisation"; or, "respond to demand for an increased range of parts"; or, "to reduce costs by carrying less inventories". In the preceding discussion, a distinction has been made between the apparatus used in cost monitoring and the standards that the apparatus monitors. This chapter has concurred with a number of writers that cost control, measures both the inputs and output of FMS. However, it has been explained that the standards of these outputs and inputs may vary according to a company's initial manufacturing objectives. This is because the definition of performance expressed in the pre-investment justification is embodied in the monitoring apparatus of the flexible budget and this, coupled with the engineer's role in the allocation of work, serves to promote the pursuit of the ends for which FMS systems are initially introduced.

As a consequence, systems introduced for reasons aligned to "Flexible Manufacturing" and "JIT" philosophy were deployed in ways that corresponded with a company's initial intentions. There were changes in the ways that systems that were introduced for purposes aligned to "Mass Production" manufacturing philosophy were deployed. However, these changes were, in the main, a consequence of changing markets rather than responses to the representations of the systems' performance by cost control. Finally, the impact of audits on FMS has been examined and it has been argued that the reason why these have little effect on the deployment of FMS is

because they are used to amplify the findings of ongoing cost control.

Footnotes.

(1) See Chapter Six, above, for details of these different manufacturing objectives.

(2) Even when new work was introduced onto the FMS there were limits to the amount of system time allowed for this purpose. This was partly to protect general levels of system utilisation; but also to allow the engineers to plan in advance when other work could be machined. The general practice for introducing new work onto the FMS once the system was operational was as follows. The engineer would decide whether or not to allocate a new part to the FMS. A decision based on information provided by sales and the cost department. Once the decision had been taken the machining instructions for the part and the programs necessary for its machining would be developed away from the system. When the parts were introduced onto the system the production departments would be allowed multiples of the base time for machining the first batch. The base time would be determined by the engineers knowledge of such factors as the nature of the raw casting and feed and speed rates of machines. Each time the parts were machined there would be a graduated reduction in the number of multiples of the base time that the production department was allowed to reflect the increased elimination of teething problems. If the initial estimation of the base time was accurate it was expected that the system would realise this time after a specified number of batches had been machined. If it was inaccurate the information would be fed back to the engineers, schedulers and cost department so that they could adjust their calculations.

Chapter Eight

8.1 Restatement of Ideas.

It was explained at the outset of this thesis that the initial idea that prompted this research project was the work of Jaikumar (1984; 1986). He had argued that the philosophy of Scientific Management was pervasive in the American companies that had introduced FMS. One of the manifestations of this was cost control techniques which emphasised machine uptime and volume of output as suitable measurements of a system's performance. In contrast, Jaikumar suggests that the strength of FMS systems, which embody the philosophy of flexible manufacturing, is their ability to machine a wide range of parts in the batch sizes that are required by customers. Realisation of these strengths may at times reduce both the machine uptime and the volume of output that is obtained. When FMS systems have been introduced, the legacy of Scientific Management inherent in cost control has prevented realisation of the true benefits of the system. Instead FMS systems have been deployed for the less advantageous end of large volume production of a limited range of parts.

Jaikumar argues that the effect of this misuse of FMS is accentuated by the level of capital intensity in American industry. Most costs are now fixed. There is only limited potential in gaining an economic advantage by increasing the productivity of the small numbers of remaining employees. By contrast, real improvements to a company's profitability may be obtained by greater expenditure on labour, which would make possible the exploitation of the flexibility in FMS by increasing the range, and by implication, the value of output.

The initial aim of this project was to apply Jaikumar's ideas to Britain, to establish whether accounting protocol did constitute an obstacle to the economic success of companies. However, Chapter One offered a critique of Jaikumar's ideas and suggested that: (i) insufficient attention is given to how engineers, as the source of change, and accountants and accounting criteria, as the impediments to that change, relate to one another; (ii) the assumptions of the intrinsic qualities of FMS coinciding with an era ripe for the exploitation of those qualities, generalise the systems and the period; and, (iii) the analysis of the deployment of FMS in isolation from the process of change that led to that deployment is inappropriate.

Firstly, it has been argued that an examination of the historical development of accounting controls in their social and organisational context, suggests that the potential for accounting to diverge from engineering systems may be limited. Where engineering and accounting functions have been separated, engineers have access to information about the shopfloor which accountants do not share. As a consequence accountants are dependent on the engineers to provide them with information about the contours and merits of production systems. Therefore, the potential for inappropriate accounting practices to be imposed on engineering systems through remote procedures or distant practitioners should not be assumed. Instead, an analysis of the application of financial controls to FMS must start with the role of engineers in the application of accounting techniques to the systems that they propose.

Secondly, it has been contended that as neither the qualities

of systems nor the period may be generalised in absolute terms, the type of economically viable deployment of FMS, and the financial benefits that arise, cannot be assumed in advance. Before the influence of accounting practices can be identified, the advantages that are likely to accrue to a company from their particular use of FMS must be established by reference to criteria that are relevant in specific contexts. In particular, the ability of a system to remedy the weaknesses in a company's existing methods of production, and the extent to which realisation of their stated manufacturing objectives precludes the realisation of other financial advantages.

Thirdly, the deployment of FMS should be seen as the culmination of a process of technical change. This process starts at the point when a company identifies a need for a new system to manufacture a range of goods in particular batch sizes. It progresses through the selection and justification of the machinery to its eventual use. Accounting practices are employed at two different stages in that process: at the point of the pre-investment evaluation; and, subsequently, at the point of cost monitoring. Whilst there will be a strand of continuity from the point when a company identifies its manufacturing needs through to the eventual deployment of the system, potential biases exist in the accounting practices employed at each stage. Therefore, the impact of each on systems introduced for different purposes must be investigated.

The research conducted has sought to understand the impact of accounting practices on the eventual deployment of FMS from within this framework.

8.2 General Overview of Findings.

Chapter Five of this thesis explained that of the nineteen companies covered by this study, fifteen belonged to corporate groups where a total of sixteen FMS systems had been introduced. At these companies a clear division of labour existed between accountants and engineers, and accountants tended to hold formally superordinate positions to engineers. However, accountants' limited access to the shopfloor resulted in engineers having responsibility for the identification of which new system to purchase and the initial preparation of its financial justification. This did not mean that engineers would express the exact financial profile of any new manufacturing system that they proposed: engineers may not have possessed sufficient understanding of accounting practices to make changes to their format; a company's executives or financial staff may have set general hurdle figures too high; accountants may rule that certain categories of savings are not legitimate. However, it does mean that engineers were, at least, provided with the opportunity to make accountants aware of the financial merits of FMS.

There were two companies amongst this category of firms that belonged to corporate groups where the likelihood of engineers expressing novel advantages in the financial justification had been increased. Executives at the respective companies had promoted the engineering function within the organisation and given engineering personnel a brief to introduce novel systems.

The remaining four companies investigated by this study were independent concerns. A hierarchy of offices between the accounting and engineering functions had not yet evolved and this facilitated

an easier assimilation of accounting and engineering information when their total of five FMS systems were introduced.

Chapter Five did not deny that biases in accounting practices may be restricting the introduction of FMS. In fact, it reported seven instances where changes had to be made to different companies' procedures. This sometimes facilitated a relaxation of financial criteria before FMS was introduced. The outcome of the adaptations was that all of the companies in this study were able to justify their introduction of FMS.

Chapter Six examined the early stages of the process of technical change and reported: the motives that companies had for installing FMS and the perceptions that companies had of the economics of manufacturing with their system; and, the extent of the different companies' success in composing a financial justification that reflected their aspirations when deploying FMS. Chapter Six reported that all of the companies in this study had previously used conventional machine tools for the production of a range of parts in varying batch sizes. However, the improvements that FMS systems were expected to bring over a company's preceding production arrangements, and the financial benefits that were expected to follow from this, varied between the different companies. All of the firms claimed to have purchased FMS to realise one or another of three manufacturing and financial objectives. Thirteen systems were introduced "to increase or maximise machine utilisation" - ie, Mass Production aligned objectives. Four firms installed their systems "to reduce the cost of stocks by carry less inventories" - ie, Just-in-Time related objectives. Finally, four systems were introduced for the purpose

of "responding to demand for an increasing range of parts" - or Flexible Manufacturing aligned objectives.

The personnel at the firms appeared to enjoy some success in adapting their financial appraisals to reflect their stated manufacturing intentions. The nature of the calculation in the pre-investment justification is to: assess the income that will be generated from the output machined on the additional capacity of a new system; quantify the value of any other financial benefits that arise from the installation of the system; and, calculate whether the aggregate total of these over the lifetime of the proposed investment outweighs the cost its purchase. A range of criticisms have been made of pre-investment justifications by other authors who suggested that the techniques of appraisal understated the lifetime, advantages and capacity of FMS.

Chapter Six reported that this study found that companies already used methods of appraisal that attributed FMS lifespans that were longer than those claimed by critics. Where short-term appraisal methods were employed previously, some companies extended their normal amortisation period to facilitate the introduction of FMS.

The discussion in Chapter Six showed that this research has found that the personnel who composed the justification of FMS were able to adapt the definition of the capacity in the justification to reflect their intended machining objectives. Thus, companies with Mass Production aligned objectives tended to justify their systems by assuming a high level of system utilisation, when machining a relatively limited range of parts in large batch sizes. The firms that introduced their systems for reasons akin to JIT

assumed a lower level of utilisation, as a means to producing in small batches. Finally, the companies that introduced their systems for purposes consistent with Flexible Manufacturing philosophy, justified their systems against its capacity to machine a wider range of goods at a lower level of machine utilisation.

It was also reported in Chapter Six that not all companies were able to translate their perceptions of the strengths of FMS into financial advantages that could be expressed in the pre-investment evaluation. The companies with Mass Production aligned objectives might not have been expected to realise any gains other than the traditional benefits of improvements in machining time and reductions in labour. These featured prominently in their pre-investment justifications. The firms that introduced their systems to pursue JIT objectives were able to justify their systems against the reductions in inventories that they anticipated.

The firms that expressed objectives aligned to Flexible Manufacturing philosophy, were, however, generally unable to express this as a category of financial advantages in their pre-investment justification. One firm did include in their appraisal a category of "intangibles", but offered no systematic way of calculating this. The remaining three companies need for flexibility in their respective systems arose from their desire to bring back in-house work that had been sub-contracted out. Thus, reductions in sub-contracting costs featured prominently in their pre-investment appraisal. However, to reiterate, they did not include a direct expression of the financial benefits of the flexibility in the system. The reason for this may be that their preceding methods of production were the flexible conventional

batch production systems. As a consequence FMS did not bring the additional quality of flexibility per se. In order to establish whether there is a weakness in pre-investment evaluations that prevents expression of a novel quality of flexibility it would have been necessary to include a sector such as the automobile industry where flexible systems have sometimes been introduced to replace dedicated machinery. Unfortunately, access for research in this sector has, thus far, been limited.

Chapter Seven examined the impact of cost control on the deployment of FMS systems. A distinction was made between the apparatus used for cost monitoring and the standards that the apparatus embodied. It was explained that the cost monitoring apparatus aimed to monitor a system's expenditure and output profile, as detailed by the pre-investment justification. The technique used for this purpose, the flexible budget, focuses on a department where the system is located. Whilst this proved adequate for monitoring the expenditure profiles that were anticipated when systems were introduced for "Mass Production" and "Flexible Manufacturing" aligned objectives, it was not suitable for monitoring the expenditure pattern that was anticipated for systems introduced for "Just-in-Time" purposes. Inventory savings had featured prominently in the justification of these systems. Departmental budgets could not track whether the expenditure on inventories had actually been reduced or simply transferred elsewhere in the company.

The flexible budget was more successful in monitoring the output profile of systems. The definition of the capacity that a system was expected to attain was transferred from the pre-

investment justification to the flexible budget. This definition of capacity provided the standards of performance that systems were expected to attain once they were introduced. Whilst, in the first instance, the output capacity was measured against the levels of system utilisation, accounts staff did have access to information on range and batch size. As a consequence, the cost monitoring machinery of flexible budgets, coupled with the engineers' role in the allocation of work, served to promote realisation of the different companies' initial manufacturing objectives. Systems that were introduced to realise Flexible Manufacturing and JIT aligned purposes, tended to be deployed in ways that were consistent with the respective companies' initial intentions. There were changes to the ways that systems that were introduced for Mass Production aligned purposes were used. However, these variations represented a reduction in the levels of productivity and tended to be market led rather than driven by the findings of cost monitoring.

8.3 Interpretation of Findings.

There are three types of issue that have been discussed in the course of this thesis which have relevance for three types of theory alluded to in the introductory chapters of this thesis. These are: (i) whether or not change to FMS confirms or refutes theories of long term trajectories; (ii) the significance of the face-to-face relationship of accountants and engineers at the firms in the study for theories of accounting; and, (iii) the types of biases identified in accounting practices and the significance of their impact on FMS for theories of the influence of accounting practices. Each will be discussed in turn.

The theories of long term trajectories that were discussed in Chapter One inferred or stated explicitly, that only one of two types of possible uses of computerised multi-purpose manufacturing systems would be viable in the long term. The first set of theories were those of "Flexible Manufacturing" (Jaikumar, 1984; 1986) or "Flexible Specialization" (Piore and Sabel, 1984). These argued that the only financially secure future option of firms, when deploying new machinery, was to produce a wide range of goods to satisfy niche markets. The alternative vision, offered by "Neo-Fordist" and "Labour Process" theorists, was an extension of the fordist logic of increasing the productivity of labour, by using the intelligence in the system to displace some workers (Aglietta, 1978) and to control those that remain (Braverman, 1974).

The majority, ie, thirteen out of twenty-one, of the FMS systems that were introduced by the companies in this study were installed for, and justified against, their ability to improve the rate at which parts could be machined and labour displaced. This could be interpreted as being generally supportive of the idea that there is a general movement towards mass production principles. In which case, this would be indicative of the scenario advocated by theorists from the "Labour Process" and "Neo-Fordist" traditions. However, the greater number of companies with these motives is more likely to be a consequence of the numerical predominance in this study of firms that employ batch production techniques; a predominance which is reflective of the pattern in the country as a whole (Gallagher, 1980; Littler and Salaman, 1984). As Chapter Three explained, the major weaknesses of this method of production are the poor levels of machine and labour utilisation.

What the different motives expressed by companies in this study indicate is, there are more potential routes to profitability than any of the different theories of long term trajectories suggest. The different authors' respective focus on the different ways in which the labour-machinery axis may be organised when manufacturing systems are deployed, leads them to neglect how the use of these resources may be combined in different ways with the profitable exploitation of stocks of raw materials, part-processed goods and finished items. This potential for different permutations in the profitable exploitation of stocks, labour and machinery highlights that, regardless of the long term developments suggested by writers who advocate "Flexible" (Piore and Sabel, 1984; Jaikumar, 1984) or "Fordist" futures (Braverman, 1974; Aglietta, 1978), there are a number of different countervailing tendencies that exist in the short to medium term. The economic and social factors that underpin the different tendencies include: the relative costs of stocks; the extent of company's sub-contracting costs; local trade union organisation; and the size and stability of a company's markets.

The second set of ideas that this discussion has relevance for are theories of accounting. Chapter Two explained that different writers have described how a range of different factors have given rise to accountants holding prominent positions in decision making processes (see Stracey, 1954; Johnson and Kaplan, 1987; Loft, 1988; 1989; Armstrong, 1987a; 1987b). This thesis has not challenged these ideas. However, the discussion here has illustrated that these theories are incomplete. Any discussion of the influence of accountants should not focus only on the source of their power. It

is also necessary to investigate any obstacles, potential or otherwise, to its administration in specific situations. The discussion in this thesis has illustrated that the administration of accountants' power is contingent on the co-operation of groups that hold formally subordinate positions, such as engineers. Therefore, the actual power of accountants is more limited than is often implied by the writers who discuss the original sources of accountants' power.

Let us turn our attention now to the third issue of the extent to which there are biases in accounting controls and whether, as some theorists have argued, these are responsible for a given pattern of deployment of FMS. This thesis has reported that there is some evidence of bias in both pre-investment justification and cost control mechanisms, although the bias is not as extensive as critics of accounting practices claim.

If the central tenets of this thesis are set aside, it is possible to view the pattern of deployment of FMS at the respondent firms as a consequence of the biases in accounting practices. Of the twenty-one systems that were installed at the companies in this study: thirteen were introduced for "Mass Production" ends; four were introduced for "JIT" objectives; but, only four were introduced for "Flexible Manufacturing" purposes. In three out of the latter four instances, FMS systems were introduced through procedures that either did not generally conform with the capital sanctioning routes described in Chapter Two above, or there was some change to that route at the time when the FMS was introduced. In other words: two installations were at firms where the engineering function had been given a more prominent role in the

capital sanctioning route; and, one other was at the company where the managing director had acted in a surreptitious manner, and instructed the production engineer to propose FMS. As noted above, none of these three companies were able to quantify advantages that expressed their systems' flexibility. This could be perceived as representing a failure in pre-investment appraisal techniques which discourage companies from introducing FMS for flexible production objectives. Such an interpretation is not contradicted by the evidence from the remaining company that had introduced FMS for "Flexible Manufacturing" purposes. Their method of quantifying the flexibility in FMS was arbitrary and unsystematic.

It is also possible to identify weaknesses in the cost control practices, and to interpret those as causing the pattern of deployment of FMS at the firms in the study. The measures that have been developed to monitor the performance of production systems have an initial structure that is analogous to, the expenditure and output structure of, work methods that are dedicated to the production of a single good. The first measure of performance that companies' cost control techniques focus on is the level of machine or system utilisation. Cost control also monitors the level of output that is produced. These measures are not inconsistent with those that have been described by writers such as Jaikumar (1984; 1986), Jones and Scott (1985) and Jones (1989), and which are alleged to encourage the use of systems for the large volume production of a limited range of parts. As many of the systems covered by this study were used to machine a finite and often limited range of goods in relatively large batches this may be interpreted as supporting the view that biased accounting

techniques promote the pursuit of mass production ends.

However, the approach of this thesis has been to adopt a sociological and processual perspective which seeks to locate each instance of technical change in its specific context. This perspective has allowed it to be demonstrated that the existence of biases in accounting practices and their coincidence with FMS systems deployed in particular ways does not provide sufficient proof that the former caused the latter.

This research found that different companies introduced FMS to pursue manufacturing strategies that were compatible with either "Mass Production", "Flexible Manufacturing" or "JIT" philosophies. The adoption of a processual approach has allowed a comparison to be made between the pattern of deployment of FMS and the companies' initial intentions for purchasing their systems. This has revealed that companies often use their systems in the ways that they had initially intended when purchasing them, rather than changing their deployment as a consequence of the application of accounting controls. The investigation of the accounting practices that are applied in the intervening process, between the selection of a system and their actual deployment, has shown that, in many instances, there is no need for those practices to be changed to express and monitor the advantages that a company sought from FMS. This suitability of accounting practices was particularly evident when companies had introduced their system to improve their previous levels of system or labour utilisation, ie, realise "Mass Production" ends, in the area of conventional batch production. Further, in some instances where adaptations to the format of pre-investment justification were necessary, companies were able to

make those alterations so that FMS could be introduced. For example, inventory savings were included in the pre-investment justifications of firms where FMS was introduced for JIT purposes. This, in turn, precipitated changes to cost monitoring techniques.

Of course, this is not the whole story. At some of the firms in this study, there remained a degree of incongruence between accounting practices - both in terms of pre-investment justifications and post-installation cost controls - and some deployments of FMS. However, a sociological approach to the application of accounting controls has allowed it to be demonstrated that accountants do not enjoy unlimited power, when applying their analysis to the evaluation and monitoring of a system. In the process of technical change other groups, from below and above the accountants in a company's hierarchy, may make interventions that facilitate the introduction of FMS. Engineers, who hold formally subordinate positions to accountants, may use their knowledge of engineering systems to identify weaknesses in accounting and to manipulate change to accounting categories. These categories are then more reflective of the merits of FMS. The ability of accountants to resist such proposals are restricted by their own limited knowledge of manufacturing operations and inability to propose alternative engineering systems.

Where accountants and accounting criteria prove to be resistant to change there are others with greater power who may overrule the initial financial evaluation. Directors can and do ignore accountants' recommendations and the hurdle figures in accounting calculations. Instead executives use other forms of discourse such as "acts of faith", "gut feelings" and "fundamental

strategies" to justify the introduction of new systems. A discussion of the limits of the power of accountants has allowed it to be demonstrated that, FMS systems have been introduced into companies where an examination of the pre-investment evaluation used, prior to the development of FMS, would suggest that it was not possible for such systems to be introduced.

The sociological approach of investigating the limits to accountants' power has also allowed it to be demonstrated that once systems are introduced, they are generally deployed for the purposes for which they were purchased, despite the weaknesses in cost monitoring. This is because accountants only supervise the apparatus for monitoring. The other groups of personnel that are discussed here are involved in defining the standards by which systems are evaluated. Thus, however incomplete the apparatus is, engineers' articulation of the standards of performance that systems are monitored against, generally means that FMS systems are deployed in accord with the companies' initial manufacturing intentions.

8.4 Suggestions for Future Research

This research was conducted shortly after FMS systems were introduced. Also, the project was, intentionally, focused on the relationship between the assumptions in the pre-investment justification and the conduct of cost control. The companies in this study have now been employing FMS for some time. The systems are no longer new. The relative increase in the length of time since the inception of this first crop of FMS systems into British firms, makes possible new opportunities for further research. In

addition, there are other routes of enquiry that may build on the work of this study. The following may offer possible options for future research.

Cost Controls - Budgets are not given on tablets of stone which cannot be changed for the remainder of time. They are re-negotiated and modified annually, depending on such factors as changing orders and past performance. Investigations into the processes of negotiation and the rationale employed to justify a certain level of budget where FMS is employed, and its comparison with the initial justification, could provide useful information on companies' changing perceptions of the economic strengths of FMS.

Diffusion of FMS - In the first half of the 1980s, the State took positive action to encourage installations of FMS. Since that time conditions have changed. Most notably, the provision of grants has ceased. However, one potential source of diffusion of systems has increased as a consequence of the early deployment of FMS. That is, the production engineers, who often initiated the introduction of these systems, gained experience of FMS and, at times, had their own competence judged by the success of the installations that they had proposed. A study of the production engineers and their subsequent activities including any further involvement in changes to new work systems could provide valuable insights into: the transfer of knowledge and experience between companies by individuals; the professional socialisation of "project champions"; and, a reflective account of the strengths and weaknesses of the early installations of FMS.

Engineers' concern with Job content - The arguments of Jaikumar suggest that it is accountants and accounting criteria that are, at

least partially, responsible for the perpetuation of the de-humanising forms of work organisation that originated from the introduction of Scientific Management. However, this research highlights the importance of the interventions of engineers to the selection of new machinery and the provision of the initial financial justification. This suggests that engineers play an integral role in either perpetuating or changing the job content of employees. The extension of research into the engineers' priorities - for example, financial, technical, humanistic - when they are selecting and evaluating new systems, could open up the possibilities for positive policy initiatives.

Sectoral Comparisons - It has been reported in this research that a number of companies expressed motivations compatible with Flexible Manufacturing philosophy, to explain their installation of FMS. However, they failed to express these advantages in their pre-investment justification. It has been suggested here that it is not possible to establish whether this was either a consequence of weaknesses in pre-investment justifications, or the companies' previous employment of the more flexible system of conventional batch production. If it was the latter, the weakness in pre-investment justifications do not exist. A comparison of the findings of this research with research into another sector, such as some areas of motor car production where FMS systems have been introduced as successors to dedicated systems, would allow clarification of this issue.

Extension of Sociological and Processual Approach to Technical Change

- This research has illustrated that sociology has a positive

contribution to make in clarifying the process of technical change and the organisation of accounting protocol in that process. This study was deliberately focused on the introduction of a novel system. It might be expected that in these circumstances there would be a degree of incompatibility between the contours of the proposed system and the predominant accounting analysis. Consequently, the probability of companies modifying, or waiving, some financial criteria are likely to be increased. An application of the approach adopted here, in an investigation of the introduction of traditional manufacturing systems, would allow it to be established whether accounting ever represents accurately the advantages of new investments. This would cast light on both the process of technical change and the general value of accounting.

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Appendix 1.

Note on Methodology.

The Problem.

Since the last quarter of the nineteenth century, when its claims to providing the "Workshop of the World" (Chambers, 1961) were being eroded, British industry has suffered a relative decline vis-a-vis the industries of other nations. In the early 1980's this decline gathered pace and a large number of manufacturing jobs, in sectors such as engineering, were lost. (See, for example, Gaffikin and Nickson, 1984a; 1984b.) A wide variety of theories have been put forward to explain this decline. These explanations range from the self-interest of footloose multinational capital shifting their production facilities overseas (ibid), to the limited efforts of British workers. (See Nichols, 1986, for discussion of the validity of this latter set of ideas.)

The fear of industrial decline that has concerned British commentators has, in recent years, found a parallel expression across the Atlantic. Writers in North America have started to worry about their own industries' eclipse by Japanese companies. One writer, Jaikumar (1984; 1986), has observed that, in contrast with Japanese companies, American firms' accounting practices are serving to hamper financially viable deployments of new computer based manufacturing systems. In British industry, as in American companies, and unlike the more successful industrial nations such as Japan and Germany, accountants hold a prominent position (Armstrong, 1987a). Thus, there appeared to be the potential for accountants in Britain to apply inappropriate accounting standards when evaluating the performance of computerised work systems. If

this happened it could accentuate Britain's poor industrial performance and hasten manufacturing decline. As the advent of microelectronic work systems constitutes part of what some commentators (see, for example, Braun and MacDonald, 1980) have described as a "revolution", any inappropriate restriction on their use at the current juncture could have catastrophic consequences in the future. The impact of accounting practices on the use of FMS was a problem with practical relevance to a large audience outside of academic circles and, thus, worthy of study.

The Research Strategy.

Two inter-related problems present themselves to any researcher who seeks to investigate the impact of accounting practices on the deployment of FMS. The first is to determine the use that FMS would have been put to had accounting practices not intervened. As FMS systems are flexible, they may be deployed for a range of different purposes. If the effects of accounting practices are to be assessed, it is necessary to define the alternative form of deployment of FMS that would have existed, otherwise. The second issue is to determine the stages at which the comparison should be made between the desired deployment and the usage that arises as a consequence of the biases in accounting practices.

The previous research in this field has not failed to give proper consideration to such questions and, so, does not provide any indication of how to address these issues. (See, Chapters One and Four above, and, in particular, Jaikumar, 1984; 1986.) Instead, the investigators have assumed, a priori, a best use of FMS on the basis of their perceptions of, either, the intrinsic qualities of

the system, or, the long term trajectory of the economy. The researchers have then compared this use with the actual deployments of FMS. Any variation in actual deployment from the conceptualized best use is attributed to the impact of cost control. Comparisons between nations where variations in accounting practices and actual deployments of FMS exist, are often used to support these arguments. (See, for example, Jaikumar, 1984; 1986). Whilst the researchers claim to study the impact of the accounting practice of cost control on the deployment of FMS, they are, in fact, reporting observations of two separate phenomena: the type of accounting practices that are present in firms in different nations; and, the forms of deployment of FMS. No link exists between the two other than that which exists in the theory itself.

This project sought to ensure that it was possible to identify the link that existed between the accounting practices of different companies and their respective deployment of FMS. To this end a "processual" approach has been adopted. The process that is assumed to exist is, a firm's deployment of a particular manufacturing system, that has been selected rationally, because it is perceived to have the machining qualities necessary to meet the firm's anticipated production needs. The reason why this author believes that this process exists is because the introduction of new machinery into any firm is purposive. Expenditure on large purchases such as FMS has to be justified to, and sanctioned by, people other than those who proposed the purchase in the first instance. Therefore, the advocates of particular projects must have a reason for selecting a given system. That reason must be understood by others within the context of that particular firm. Of

course the original conception is subjected to a number of pressures that may divert the process from its originally defined path. These pressures include technical, social and economic factors, as well as the organisational influences that includes the application of accounting practices. Ideally, the researcher would investigate all of the other pressures so that each may be isolated. It would then be possible to identify the exact impact of accounting practices. However, the potential sources of influence are so great in number and so varied in type, researchers are never able to investigate them all. (See, Weber, 1949, for further discussion of this problem.)

The approach that has been adopted here has been to examine a series of stages in the process of technical change to FMS: from the initial impetus for its selection; through the application of accounting techniques; to the final deployment of the system. The stages that are examined are: (i) the company's initial reasons for selecting FMS, as expressed in their manufacturing strategy, and perceptions of the strengths of FMS; (ii) the employment of the pre-investment evaluation and its capacity to express, in financial terms, a company's aspirations when justifying new systems; (iii) the nature of the cost control mechanisms employed, and their ability to monitor the dimensions of performance of FMS; and, (iv) the actual performance of the system once operational. The changes between a company's initial intentions and their actual deployment of FMS, that have arisen as a consequence of biases in accounting practices, have been established by: a comparison between the intended and actual use of FMS; an investigation into the extent to which accounting practices failed to express a company's

manufacturing objectives for their system; and, an enquiry into the alternative reasons for changes in the deployment of the system.

(1)

There are a number of benefits that arise from adopting this approach of investigating the application of accounting practices as part of a longer process of technical change. Firstly, by identifying the initial intended use of a system at different companies, it is possible to identify the range of trends that exist within the general phenomena of change to FMS. Secondly, by examining the biases in accounting practices employed at different stages in the process of change, it is possible to identify the exact source of any mis-direction by accounting practices and any incremental growth in any mis-use of FMS that may arise through biases in more than one practice. Thirdly, by studying specific practices it is possible to make comparisons between firms: This is important because human behaviour is idiosyncratic and unique and does not lend itself to comparative analysis. However, the types of institutions and practices that human beings develop often gives rise to behaviour of a standardized form (Goldthorpe, 1973). Accounting practices, which act as a restriction on courses of action within different firms, provide a force that serves to regularise activity. A study of the presence of accounting practices at comparable stages in the process of technical change, allows that process to be examined at a whole range of different companies. This permits comparisons between the different firms, despite their unique and individual facets.

At first sight this topic, which aims to investigate a process of technical change that spans a lengthy period, would appear to be

an ideal subject for a conventional longitudinal study. Such design is, in fact, impractical because of the following reasons. Firstly, the length of the process cannot be pinned down to a finite period in advance. Most research projects only provide funds for a limited period. It is extremely difficult to reconcile the period of the research project to that of the process of technical change at any one company. These difficulties are multiplied when the investigator seeks to conduct comparative research and has to study change at several firms. Secondly, many companies that plan new systems often fail to introduce them. Resources spent investigating such firms could produce material that is of little relevance to the question under investigation.

In order to overcome these problems this research elected to study firms that had already introduced FMS. In some instances of social research, when sufficient information has already been collected and the situation is relatively static, it is possible to: define in advance the contours of the population to be studied; select representative parts to investigate; and, then employ statistical analysis to assess the probability of the responses and trends being reflective of those existing in the population as a whole. Thus, any theory that is derived from the pattern found may be considered to be applicable to the whole population.

The population of firms that had introduced FMS was in a state of flux. FMS was a new system. The small number of companies that possessed such configurations multiplied over a relatively short period, partly as a consequence of the provision of Government grants. Thus, the designated population was not only changing in composition but very little was known about many of its constituent

parts. Indeed, even identifying which firms fell into that population was extremely difficult because previous researchers in the field disagreed on what constituted an FMS system. (See, for example, Scott, 1987; Browne et al, 1984; Gerwin and Leung, 1981.)

It was, therefore, necessary to investigate individual cases as entities in themselves rather than as representatives of a wider population. This type of research does have its merits. It is exploratory and extends the knowledge of the population under investigation. This is a pre-condition to any research that can claim to be representative of the wider population.

Exploration is only part of the value of the case study approach adopted here. Theoretical understanding of the population studied may be enhanced. Whilst it may not be possible to claim general applicability of a theory on the basis of one or more case histories (cf, Durkheim, 1976), it is possible to refute existing arguments, depending on the empirical evidence gathered. (See, for example, Goldthorpe et al, 1970.) Of course, refutation can be a negative exercise. If alternative ideas are proposed, it is possible to develop the original thesis through a dialectical interplay with one or more antithesis. This is how this project has sought to develop theory. Jaikumar's (1984; 1986) ideas, which were developed in the USA and which argued that the deployment of FMS systems were being affected by cost control practices, were refined prior to the conduct of this research in Britain by the proposals that: (a) engineers' understanding of engineering systems, coupled with their role in preparing the initial financial evaluation of a proposed purchase, provide a counterweight to biases in accounting techniques; (b) the economic gains of FMS to be articulated and

monitored by accounting practices cannot be defined by some absolute criterion, they are contextual and relative to each individual company's production facilities and future manufacturing strategy; and (c) the final deployments of FMS are also influenced by pre-investment evaluations which may, either, promote a company's original aims, or, if there are any biases in these practices, encourage particular types of deployment of FMS that are different from those that were originally intended. Through this refinement of the original theory, it has been possible to develop an alternative set of ideas that are able to explain the pattern of empirical evidence gathered in the course of this research.

It may also be added that whilst this thesis does not claim to report cases that are representative of the population as a whole, the number of companies that constitute the wider population is relatively small. The nineteen firms with 21 systems that are included in this study constitute between one-third and one-fifth of the total population of companies that possessed FMS at the time that the research was carried out. (Estimate based on private correspondence with DTI, October, 1987.) The trends identified here may, therefore, be seen as relatively significant when perceived against the backdrop of a small population.

The Research.

Fieldwork was carried out at two points in this project. Empirical evidence was first gathered in the form of a pilot study. This sought to assess the relevance of the issues to be researched, the adequacy of the interview schedule, the suitability of the class of respondents for the issues investigated, etc. The pilot

study took place between June and October 1986 when five companies that had installed FMS were visited. At different firms, executives, accountants, engineers, operations managers and shopfloor staff were met. This stage of the research confirmed that the accountants and the engineers were the personnel who would be most useful in the conduct of this research. Apart from the two firms that were subsequently visited again in the course of the main study, the information gathered from these firms are not reported in the text above. (2)

The main study of the field work was conducted in the course of 1987. In total, 21 firms were visited. Whilst two of the companies were intending to introduce FMS, their plans had not come to fruition at the time of the research visits. There was no indication that this was a consequence of accounting practices. They had carried out an initial financial evaluation of the system and were still intending to purchase FMS. As the concern of this thesis is the impact of accounting practices on the actual use of systems, the information gathered at these firms has been excluded from the analysis and discussion. This left a total of nineteen firms. Seventeen of these companies had each introduced one FMS and two others each possessed two systems. Over a ten month period, in the course of 1987, eighteen of the companies were visited once and Brit Machine Tool Co. was visited twice. Thus, when the pilot study visits to Diesel Engine Co. and Coal Co. are included, sixteen of the firms in the main study were visited once and three companies were visited twice.

As the objective of the research was to investigate the nature of conflict between accounting and engineering rationales, attempts

were made to interview both the engineer responsible for the initial selection and financial proposal of the FMS system and a member of the accounting staff. (3) This was possible at ten companies. At eight of these firms additional interviews were conducted with other members of staff. This included one of the directors at **Miner Co.**, where the introduction of FMS had been reported to originate from the board. A director was also interviewed at **Brit Machine Tool Co.**, where negotiations for a 70% grant towards the cost of FMS took place between board members and a Government agency. In the course of each visit, attempts were made to speak with accountants and engineers separately so that any divergence and conflicts of opinion could be expressed by each respondent, without fear of contradiction by the other. At three of the ten companies this was not possible; the engineer chaperoned me in my meetings with accountants at **Soot Co.** and **Industrial Vehicles Ltd.** and the accounting staff accompanied me in my meeting with the engineer at **For Machine Tool Co.** The general pattern of responses received from these companies tended to confirm, rather than diverge from those received from the other companies. In effect: the perceptions of the strengths of FMS held by accountants and engineers tended to conform with one another; engineers had more detailed knowledge of shopfloor operations; and, accountants tended to have more knowledge of the intricacy of higher levels of financial decision-making. The parallel findings at the different companies where accountants and engineers were interviewed both together and alone suggested that there was no value in presenting these findings separately. As a consequence, they are reported together in the text. It should be added that, the opportunity to

interview some accountants and engineers together proved to be a blessing in disguise. It served to demonstrate how the parameters to each group's domain was manifest in practical situations, when interaction took place.

At three of the remaining nine companies - ie, Alloy Corp., Boiler Co. and Print Co. - it was only possible to interview accounting staff (although at Print Co. both the company's accountant and the Financial Director were interviewed). To some extent the significance of this is limited at Alloy Corp. where the FMS system had been instigated and constructed at the company's Research and Development division and was not initiated by the company's in-house engineering staff. At the remaining six companies - Marine Co., Coach Co., Nat Air Co., Motor Co. Gear Co. and Coal Co. - engineering staff were interviewed but accountants were not. At four of these companies, Coach Co., Nat Air Co., Motor Co. and Coal Co., additional interviews were held with other production management staff as a means to assessing the validity of the claims of the initial interviewees.

At all of the firms semi-structured interviews that followed a pre-set schedule were conducted when accountants and engineers were met. In effect, a pre-defined set of topics were covered at each of the companies but the order of the questions, and the areas expanded in the course of the discussion, varied according to the specific contingencies of the firm visited. As the research was concerned with engineers' and accountants' contribution to the same process, the interview schedule designed for each of the different groups covered many of the same topics.

The interview schedule with the engineers covered the issues

of: the company's manufacturing interests; the respondent's responsibilities; the background to the decision to select and invest in FMS; the type and design of system purchased; the time scale from the conception of FMS to its final commissioning and operation; the work that the system was purchased to machine and the standards of performance in terms of output that this represented; the content of pre-investment justifications and each engineer's awareness of the financial criteria that any new investment had to meet; the engineer's contribution to, and awareness of, the capital sanctioning route; the nature of the financial monitoring procedures and the engineer's awareness of other financial calculations such as overhead allocations; the actual performance of FMS; the engineer's perceptions of the merits of the FMS's current performance and the reasons for any divergence from planned use; and, the procedures for introducing new work onto their company's manufacturing facilities, including FMS.

The interview schedule with accountants covered the issues of: their knowledge of FMS and other production systems that their particular company were using and considering at the time of the field visit; their perceptions of the capital sanctioning route, both for FMS and for other systems; the content of the financial justifications for different systems including FMS; the financial criteria that a company generally used to assess the merits of a new investment and the reasons for any changes when FMS was introduced; details of cost control and overhead allocation mechanisms and any changes to these that were necessary following the introduction of FMS; the respondent's perceptions of the performance of FMS and their possible recourse to action if they

were not satisfied with that performance.

Apart from with all of the respondents at Brit Machine Tool Co. and with the engineer at Diesel Engine Co., all interviews were tape-recorded. It took between 45 minutes to three hours to cover the interview schedule with engineers. The most common time was around two hours. Interviews with accountants lasted between thirty minutes and two hours and the most common time was just over one hour.

In addition to the details of firms gathered through interviews with accounting and engineering staff, interviews were conducted with other personnel if the discussions with the initial respondents suggested that this would be necessary and/ or when there was the opportunity to do so. These interviews did not have a pre-conceived schedule but were used to clarify issues. In addition to the interviews, documentary evidence - particularly that pertaining to financial protocol, investment in, and monitoring of, FMS - was sought from the firms when appropriate. Impressionistic evidence based on observations - in particular, perceptions of relationships between accountants and engineers - was also noted mentally and reproduced in a notebook at the end of the visit. If appropriate, a respondent from the firm would be invited to comment on the impression. In addition to the information gathered at the companies: relevant journals were searched for information on the respective firms; and, research by other investigators at Bath University (Scott, 1987; Jones and Scott, 1985), who had also examined the deployment of FMS at some of the respondent firms, was also consulted.

The information available has made possible the construction

of detailed case studies of the respondent firms before the relevant details have been reported in the text above. The wide sources of information that were available has also helped to overcome some of the perennial problems of research of this type. These are: whether it is possible to trust that a single respondent's memory is correct; and, who is to be believed when there appears to be contradictory accounts of the same event being recalled. When the claims of any individual member of staff have not been corroborated by, either, interviews with other personnel at the same firm, or, evidence from another source, they have either been excluded or the text of the thesis draws attention to the potential limits to the validity of the claims.

Extent of Coverage of the Study.

The companies were selected for study on the basis of their purchase of FMS. Suitable firms for investigation were identified through a number of sources including: colleagues at Bath University who had already visited some of the respondent firms; articles in the financial and technical press that reported installations of FMS; information provided by Government agencies; and, word of mouth from respondents who knew of installations at other companies. Although the firms were not selected for study in any systematic way the large number of FMS installations investigated in the course of the research did result in the study of a wide cross-section of companies. The size of the companies' workforce ranged from less than 100 up to several thousand on the sites where FMS systems were introduced. The companies ranged from small independent firms to British based corporations to

subsidiaries of foreign multinational corporations. This, in part, reflected another variation. Some companies were experiencing growth, whilst others were in a stable situation or in decline, when defined in terms of volume of output and/ or numbers employed.

The companies studied also covered a wide area in terms of their geographical locations and in the area of engineering which they catered for. Each of the regions in the United Kingdom, apart from Northern Ireland, was the home of at least one company. The numbers of companies that fall into the different Sic groups of engineering and manufacturing activities were as follows:

Group 314:	1
Group 322:	3
Group 325:	5
Group 327:	1
Group 328:	5
Group 351:	1
Group 353:	1
Group 364:	2

Source of Classification: Employment Gazette, October, 1989.

Despite the spread of companies from across the different criteria discussed above there are limitations to the claims being made in the thesis. These are in addition to those that stem from the general limitations on theory that arise from the case study approach, discussed above. The reader should be aware of these and should not attempt to generalise these findings to areas where no inference is intended by the author.

This thesis discusses the applicability of accounting criteria when used to assess the merits of FMS in a range of contexts. As reported in the main text of the dissertation all of the installations of FMS in this study were introduced into firms that had previously employed batch production techniques. The gains that

FMS offers over these systems are largely productivity and inventory related. Any prejudice in accounting techniques that favour the expression and monitoring of productivity gains, are likely to be less apparent, at the firms studied, than, at other firms, where FMS offered gains of flexibility over the preceding manufacturing configurations. Therefore, the findings above cannot be generalized to instances where the installations of FMS were preceded by mass production methods which may have resulted in FMS improving the flexibility of the company. (4) Similarly, the arguments above describe instances where the companies already possessed manufacturing facilities which FMS systems were expected to improve upon. The same situation does not exist when FMS are being introduced into new companies. In these companies accounting practices may prove to be more or less restrictive.

Another proviso to these findings arises directly from how the firms were selected for study. All of the companies had introduced FMS successfully. The study did not research companies that had not introduced flexible manufacturing systems (apart from the two firms alluded to above that were still intending to introduce FMS). This does not mean that other firms have not considered purchasing FMS and failed as a consequences of the biases in accounting practices. Therefore, it is possible that the firms investigated by this study are exceptional because accounting practices have not prevented their deployment of FMS.

Finally, the purpose of this research was to investigate accounting practices. However, accounting is also a way of looking at the world. If respondents have internalized the logic in accounting techniques, they may dismiss purchase and certain types

of deployment of FMS without giving them proper attention before applying the practices. Therefore, it may be that, it is only in situations where FMS promises productivity gains, that specific accounting techniques are ever applied in practice. Apart from the evidence, where engineers are proposing changes to accounting practices to accommodate certain types of deployment of FMS, no claims are being made about the extent to which traditional accounting criteria have not been internalized by engineers. This thesis is addressed simply to the question of explicit practices.

Footnotes.

(1) The point at which the performance of the system is taken to be typical of the systems use is that which was defined by the companies as typical at the time of the fieldwork visit. As the different systems had been introduced at different points over a period of, approximately, six years, there was some variation in the length of time that different systems had been operational. As a consequence there was the possibility that more factors would intervene and increase the possibility that the systems of some companies would be used differently to what was intended for reasons other than accounting practices. However, it did also mean that the interviewees' recollections of how a system was being deployed were more likely to be accurate. Also, as noted above, explanations for variations in the deployment of FMS from that which was initially intended, other than the influence of accounting practices, were sought from the respondent firms.

(2) There is nothing in the information gathered at the other firms visited in the course of the pilot study to suggest conclusions other than those reached by the discussion in this thesis.

(3) It will be recalled from above that the pilot study had confirmed that the key personnel articulating these rationales were accountants and engineers.

(4) All researchers experience limits on their time and resources. Identifying and negotiating entry to firms that have previously employed mass production techniques in the hope that they might reveal a pattern that is different to that found at the companies that have been visited constitutes a double gamble. On the one hand access may not be granted and so resources that could have been spent investigating other cases will be lost. On the other hand, as many firms employ a range of different mass production and batch production techniques, the firms will not provide any outstanding insights if their system has been introduced into an area where batch production techniques have been employed previously. As this research was exploratory, and all cases could help to illuminate

the process of technical change to FMS, the strategy adopted was to research as many companies as possible, rather than risk wasting resources in vain pursuit of possible anomalies to the trends identified at the firms that were studied.

Appendix 2.

Chapters Five to Seven contains details of the financial investments of the firms of the study. Further details of Marine Co., Coach Co., Dual Air Co., Brit Machine Tool Co., For Machine Tool Co., Gear Co., the first system at Diesel Engine Co., Nat Air Co., Coal Co. and Scot Co. may be found in Scott (1987). These appendices contain some minor background information on the firms in the study. Detailed financial information is omitted for reasons of confidentiality. The order of the case studies conforms with the chronological sequence of the visits made to the different companies.

Marine Co.

Marine Co. was part of the same group of engineering companies as Diesel Engine Co. and Motor Co. It was situated in the North-West of England and manufactured diesel engines for the power generation and marine industries.

The motivation for purchasing FMS was to increase output by reducing the number of tool changes. The company had purchased the system as replacement capacity for a number of conventional machines that were being decommissioned. However, work was transferred from the conventional machines onto the company's existing CNC machinery. The larger batch work that had been on the CNC machine tools was transferred to the FMS. The company had initially planned to introduce an FMS containing four machining centres. At the time of my visit there were only three machine tools in the system.

The company had made a number of minor changes to their

accounting practices either to facilitate, or as a consequence of, their introduction of FMS. Their normal payback period had been extended from two and a half to three and a half years. The company also switched the FMS operatives from a piecework payment system to measured daywork. Machine hours were used to monitor the output and performance of the machinery at the firm, including the FMS.

Coach Co.

Coach Co. had been part of a nationalised group of companies involved in the manufacture of motor vehicles. This particular company manufactured coaches and was situated in the North-West of England.

The motivation for introducing FMS was to improve on the levels of machine utilisation that the company would otherwise have obtained from conventional machine tools when manufacturing the parts for a new range of gearboxes. The company had introduced a five machining centre system. The company did not make any significant changes to their accounting practices, either, immediately before, or, when, FMS was introduced. The company's general practice was to vary the payback period according to the nature of the equipment purchased. Thus, FMS was justified over the company's maximum amortisation period. Machine hours were used to assess the performance of the FMS, once introduced.

Scot Co.

Scot Co. was the division of a multi-national group involved in the manufacture of mining equipment. It manufactured underground coal mining equipment and was situated in an industrial area of one

of the major Scottish cities.

FMS had been introduced because it allowed the company to carry less stocks and to improve market response by reducing lead times. The company had introduced an FMS comprised of six large machining centres. No changes had been made to the company's normal accounting criteria when FMS had been used. It was still expected to realise a DCR of 30% over a 7 year period.

The general method that the company used to monitor the performance of production systems was to investigate the output that was produced in a given number of machine hours. They continued to use this method to monitor the performance of the FMS. This was a source of friction between the production engineer and the accountant. (See text of thesis for full explanation of this.)

Dual Air Co.

The company is a producer of parts for the aerospace industry. At the time of the introduction of FMS it was owned 52:48 % by two corporations. It is situated across two sites in the West Country. The majority of the work goes to the defence industry.

The motivation for introducing FMS was to maximise output by reducing set-ups and run-times to a minimum when producing a number of parts for a new contract. The system introduced was comprised of three machining centres. The company's normal practice was to amortise capital over the length of the contract for the work machined. FMS was no exception to this. No other modifications were made to the costing system. Machine hours were used to assess the performance of the FMS.

Nat Air Co.

The company is one site of a division of a former nationalised company manufacturing for the aerospace industry. It is situated in the North-West of the country. Its largest single customer is the Ministry of Defence. The system installed was one of the largest and most expensive covered by this study and was organised around ten machining centres.

The main motive for introducing the system was to respond to markets that were demanding an increasing range of goods but one of the advantages that FMS offered was the ability to machine to the tighter tolerances demanded by their customers in the defence industry. These often provided rigid specifications of the quality of the parts to be made. These stipulations served to limit the type of adaptations that a company's personnel could make to the range of parts machined on the FMS. The FMS was also purchased because it offered the company the opportunity to reduce the amount of stocks carried.

The general practice of the company was to justify new systems on the stock reductions that they facilitated against single projects. These were what the company termed "project" investments. The FMS was expected to bring reductions in stocks to a particular process which machined the parts for a wide range of projects. In this sense it was a "process" investment. The company generally used DCF calculations to justify systems conducted over 10 - 15 years depending on the anticipated life of the project. The time allowed for recovery on the FMS fell in the middle of this. DCRs of 30% were reported. The general system of monitoring the FMS was by machine hours. This was the same measure that the company used for

all machine tools of a later generation than Numerical Control. The personnel did express a desire to introduce a cell rate but had not, as yet, devised a suitable method for calculating this.

Brit Machine Tool Co.

Brit Machine Tool Co. was part of a small group operating in the metal working industries. The majority of the group was situated in the South-East. The company that had purchased the FMS was a manufacturer of machine tools.

The FMS was comprised of nine machine tools. Although the company sought an improvement in machine utilisation by introducing FMS, the main impetus for installation of the system had been the provision of a Government grant that offered recompense for any additional costs that the company incurred as a consequence of using FMS. instead of the company's normal conventional machining centre.

The firm generally sought payback of an investment over the length of given contracts. However, the FMS was reported as not being viable without the Government grant when assessed over 15 years. (This was between four and five times longer than the periods used most frequently.) The company monitored the efficiency of the system by the investigating the sum of output that was produced over the number machine hours that were available.

Trans Co.

The company was a small independent firm situated on the outskirts of a Northern Welsh City. Its main line of business was the production of components for industrial vehicles and 70% of its

production went to its major customer, **Industrial Vehicles**. (See below.)

The FMS was one of the largest and most expensive in the study and was comprised of ten machining centres and auxiliary machines. Prior to the introduction of the FMS the company had only produced axles. The firm had won the contract to manufacture gearboxes and, thus, they needed to increase their production capacity. FMS was selected as part of this expansion because it allowed the company to obtain high levels of system utilisation, when machining the range of parts necessary for both the gearboxes and axles.

The method of appraisal that the company used was payback periods of up to four years for large investments. The FMS had promised returns over 3.2 years. The manufacturing performance of systems was measured against the machine hours consumed in obtaining a given level of production output.

Small Motor Co.

This gear manufacturer is situated in the South of England. At the time of their installation of FMS they had been a small independent company.

Prior to the purchase of FMS, 80% of the company's parts went to its main customer, a major manufacturer of motor vehicles. The customer was seeking to improve some of their product range. The company tendered for the contract to produce a new range of gearboxes required in high volumes. When the company won the contract they looked for a system that would enable them to manufacture the parts in large volumes and selected FMS because it offered the additional advantage of machining to tighter

tolerances. The system comprises four machining centres and auxiliary facilities.

The general method of appraisal used was payback. This had been extended from a limited period of two years up to five years to facilitate the introduction of FMS. The introduction of FMS led the company to switch from labour to machine hour measures when monitoring the performance of a system.

Miner Co.

Miner Co. was a division of wider group producing cutting and drilling equipment for the mining industry and lighting equipment for the petro-chemical industry. The firm visited constituted the company's cutting division and was situated in the North-East.

The company was concerned with their levels of efficiency and costs. FMS was introduced because it allowed the firm to: (i) reduce costs by reducing stock levels; (ii) improve market position and response time by reducing lead times; and, (iii) improve efficiency by introducing night-shift working. The local Trade Unions had resisted this, previously. FMS allowed the firm to operate through part of the night shift with a skeleton staff when, hitherto, the factory had been shut.

The firm perceived only limited opportunities to exist for flexible manufacturing because of design constraints imposed by their major customers whose work environment was extremely volatile. The system purchased was one of the more limited configurations. It incorporated only two machine centres with a number of auxiliary machines.

The general method that companies used for assessing the

merits of a new system was payback. The production engineer described the amortisation period allowed in the following terms: "Two years are desirable. Three years is becoming touch and go. Above that, it's becoming dodgy." However, the directors had initiated the introduction of FMS and a payback period of four years had been allowed. Machine hours were used to calculate the performance of the system. The company used a bonus payment system and had to negotiate a special weighting for payments for FMS operatives to take into account the higher output from the system.

For Machine Tool Co.

The company is the European base of a North American multinational corporation. Their main products are machine tools. The factory is situated on the outskirts of a West Midlands city.

The company had installed FMS to improve on the levels of machine utilisation that they obtained from their existing machine tools when machining larger batch work. They also wanted to develop their own range of FMS systems and was seeking to use their installation as a demonstration tool. The system was one of the smallest included in this study and was comprised of only one machining centre with a number of auxiliary machining facilities. However, one of the selling points of the system was its modular design, and the company hoped to add additional machining centres as demand for their products increased.

The company conducted DCF calculations over 10 years and expected DCR's of 20%. The anticipated return on the FMS system was less than this at 11.14%. The engineer reported that an audit had been performed on the system and this indicated that the

anticipated return was being achieved. The company had previously assessed the merits of manufacturing systems' ongoing performance against the levels of labour employed. They switched to machine hours for monitoring the FMS system. A bonus system was in operation and FMS operatives were included in this. However, the company adjusted the weighting in the payment to reflect the greater output from the system.

Motor Co.

The company was situated in a large town in Yorkshire the North-East. It was a subsidiary of the same British based multinational group that owned **Marine Co.** and **Diesel Engines Ltd.** This firm manufactured electrical engines both for heavy industrial and domestic usages.

The company was having to purchase new systems to replace a number that were coming to the end of their useful life and its purchase of FMS was part of this program. The system was purchased to obtain high levels of system utilisation in the machining of casings for the companies engines. It comprised four machining centres and a number of auxiliary machining facilities.

The principle method of evaluation was payback calculated over a period up to five years. However, it was also common for the accountant to conduct a DCF calculation and include the findings of this as a "rider". The FMS had promised returns within the company's normal payback period. The company did not have to change its method for monitoring the performance of the system, once installed. They continued using their normal method which was to evaluate output performance by the number of machine hours used.

Alloy Corp.

The company was the British division of a Canadian based multinational. The main business of the division in the UK was the manufacture of extrusions. The attraction of FMS was that it allowed the company to machine a wide and increasing range of hollow extrusion dies for new markets. The installation of the FMS also allowed the company to bring back in-house a number of their range that had been previously been sub-contracted out at high expense.

The system was comprised of three machining centre systems. The FMS had been developed at the owning corporation's own Research and Development Division.

The company generally used payback calculated over two years to assess the value of new systems and included DCF calculations as riders. However, as the FMS system was developed by a Division within the corporation the pre-investment was not used to indicate whether purchase of the system should go ahead. Despite this, the system was expected to pay for itself, over the normal amortisation period, once operational. The company generally used machining hours to monitor the performance of departments and no change was made prior to the introduction of FMS.

Industrial Vehicles Ltd.

The company was an independent firm based in the North-West midlands. Its main area of business was the production of excavating equipment. The company classified their products into two types, depending on the size of demand, large volume and small batch work. Both of the FMS systems were installed to maximise

machine utilisation when machining parts in high volumes for the products that went to large-scale markets.

The first of the company's FMS systems was comprised of three machining centres and a robot welding cell. It was being used to machine ram cylinders. The second system was comprised of two machining centres and was being used to machine kingposts and carriages.

The company generally used payback, conducted over two to three years, to evaluate the worth of a new investment. Both FMS systems were justified using this method. For cost control purposes, the factory was divided into two. The assembly area was labour intensive. Thus, labour hours were used as a measure of performance. The machining areas, which were where the FMS systems were situated, were measured against the machine hours consumed. No changes were made for the monitoring of the FMS systems.

Gear Co.

The company is a subsidiary of a North American multi-national corporation. It is situated in the middle of Scotland. The main business of the subsidiary company is the production of gear pumps.

The parent company was in the process of shifting some of its production from its base in North America to its Scottish subsidiary. Hitherto, production in North America and subsequent importation of products into Europe had made the price of their goods uncompetitive. The subsidiary company selected FMS because it promised a high level of machine utilisation. The system was comprised of three machining centres, an inspection machine and a number of robots performing supporting operations.

The company generally sought payback of an initial investment over two years. However, the best possible projection with the FMS was three years and it was anticipated at the outset that this was unlikely to materialise. The company were prepared to extend the maximum payback period up to five years in order to facilitate the introduction of FMS. The company used labour hours for cost monitoring purposes and made no changes as a consequence of introducing FMS.

Small Machine Tool Co.

The company was a small independant machine tool manufacturer situated across two sites in the East of England. It was owned by a single family.

The FMS system was one of the smallest and least expensive configurations in the study. It was comprised of the company's own five face machining centre supported by a number of auxiliary machining facilities. The reason for constructing the FMS was that, prior to the installation of the system, the company's product took four to five weeks to reach the fitting shop. This created a heavy strain on the company's cashflow because each raw casting cost in excess of £2,000. The desire was to reduce this time to days to facilitate marked savings in inventory.

No full financial evaluation had been conducted on the system. The company were aware of the types of savings that would arise. They also had to give the DTI an indication of the cost of the system in order to obtain a grant. However, they never assessed whether the revenues that would be generated outweighed the costs. and over what type of period. The company generally monitored the

performance of systems against the machine hours that were used to realise production output and they did not alter this method when monitoring FMS.

Boiler Co.

Boiler Co. was the head of a division that belonged to a British corporation with interests in building, electrical and general engineering. It was situated in the North-West and manufactured immersion heaters.

FMS had been introduced to machine immersion heater lids. The company's preceding method had proved inefficient. It had required two processes: The burrowing of the lid on the lathe and the brazing on of connections. Previously, both had taken a long time and required a high level of labour. The company hoped that, by introducing FMS, they would be able to integrate the operations into a single process and obtain the highest possible level of machine utilisation. Further, the firm machined metric and imperial sized lids for British and European markets respectively. The introduction of FMS allowed the company to phase out the imperial sizes gradually.

The company used DCF on all projects over £10,000 and aimed to obtain a DCR of between 20 - 30%. FMS was assessed by this method. The company generally used labour hours consumed to monitor the merits of output from a given department and they made no changes to this method as a consequence of introducing FMS.

Diesel Engine Co.

The company belongs to the same corporate group as Marine Co.

and Motor Co. It is situated across three sites in the South-West. The main line of business of this firm is the manufacture of diesel engines for industrial use.

The company had purchased three systems (although only two are included in the study). The systems were introduced as part of an overall manufacturing strategy. Each were designed to machine parts of particular batch sizes and ranges depending on the size of the markets that the products went to. The first FMS system was introduced to machine a small range of parts required in large batches; the third was to machine a wide range of the small batch work; and, the second was to machine a range that fell somewhere in between the two. The general rationale given for the introduction of the systems was to increase the efficiency of production facilities in a situation of less predictability whilst bringing work that had been sub-contracted out back in-house. The emphasis for the introduction of the first system was to increase efficiency whilst the emphasis on the latter was to respond to the less predictable situation. The capability of machining to tighter tolerances also featured in the justification of the first system. As reported in the text the initiative for FMS had come from the Managing-Director acting through the proxy of the Production Engineer. Interviews were held with the accountant, the production engineer and other members of the engineering staff. Thus, only their version (which is the formal one) of the rationale for selecting FMS may be reported.

The FMS systems ranged in size: The first was built around four machine tools; the second around six lathes; and the third encompassed three machining centres.

The main justification technique that the company used was payback with an official maximum of four years; although, the production engineer reported working to an unofficial maximum of three. Additional calculations of DCRs were conducted by the accountant, but the key justification indicator was the payback period. The method of monitoring the performance of the FMS systems at the cost control stage was against the number of machine hours consumed to produce a given output.

Coal Co.

The company was part of a group involved in the manufacture of equipment for the mining, aerospace and general engineering industries. This firm was situated in the South-West and manufactured mining equipment.

The FMS system comprises four machining centres and additional facilities. The main reason why the company had introduced FMS was to increase the range of products in response to changes in overseas markets. FMS had been evaluated by DCF calculated over a ten year period. This was the technique that the company generally used when assessing the merits of any investment that exceeded £million. The DCR sought was 15%. A number of novel savings had been included in the justification of the system. The company generally used machine hours for monitoring the performance of systems, once installed, and they did not alter this method as a consequence of introducing FMS.

Print Co.

The company was part of a wider corporate group involved in

the engineering industry. The firm was situated in the East Midlands and its main line of business was the manufacture of printing presses.

The cost of the company's product to their customers was between £1.5 million and £4 million in 1987. As a consequence their customers sought to delay their commitment to such heavy capital expenditure until the last possible moment. This created the impetus for the firm studied to seek ways of reducing their lead times which stood at about twelve months in 1982. The firm was also seeking to improve their cost efficiency on their high value items by reducing inventories. These two factors provided the motivations for installing FMS.

The FMS system comprised six different machining centres. Each constituent part was justified individually by the company's normal techniques of DCF calculated over 10 years with an anticipated DCR of 25%. The prevailing method of cost control was to monitor the performance of systems by machine hours. However, the company's main concern, after introducing FMS, was to monitor inventory savings. They were in the process of introducing MRP (ii) as a means to achieving this.